

717 C 15

719 K 37

BOOKS printed for **JOHN OSBORN** and **THOMAS LONGMAN**, at the *Ship in Pater-noster-Row*.

A New Practice of Physic; wherein the various Diseases incident to the human Body are orderly described, their Causes assign'd, their Diagnostics and Prognostics enumerated, and the Regimen proper in each delivered; with a competent Number of Medicines for every Stage and Symptom thereof, prescribed after the manner of the most eminent Physicians among the Moderns, and particularly those of London. The whole formed on the Model of Dr. Sydenham, and completing the design of his *Processus Integri*. The Second Edition. In Two Volumes. By *Peter Shaw*, M.D. 8vo.

The Philosophical Works of the Honourable *Robert Boyle*, Esq; Abridg'd, Methodiz'd, and Dispos'd under the general Heads of Physics, Statics, Pneumatics, Natural History, Chemistry and Medicine. The whole illustrated with Notes, containing the Improvements made in the several Parts of natural and experimental Knowledge. By *P. Shaw*, M.D. in Three Volumes, 4to.

Pharmacopœia Officialis & Extemporanea; Or, a Complete English Dispensatory, in Four Parts. Containing, 1. The Theory of Pharmacy, and the several Processes therein. 2. A Description of the Official Simples, with their Virtues and Preparations, Galenical and Chymical. 3. The Official Compositions; being such of the London and *Bates's* Dispensatory, as are now in use; together with some others of uncommon Efficacy, taken from the most celebrated Authors. 4. Extemporaneous Prescriptions distributed into Classes suitable to their Intentions in Cure. By *John Quincy*, M.D. The Sixth Edition, very much improved. 8vo.

Lexicon Physico-Medicum: Or, a New Medicinal Dictionary, explaining the different Terms used in the several Branches of the Profession, and in such Parts of Natural Philosophy as are Introductory thereunto; with an Account of the Things signified by such Terms. Collected from the most eminent Authors; and particularly those who have writ on Mechanical Principles. By the same Author. The Third Edition, with new Improvements from the late Chymical and Mechanical Authors. 8vo.

Medicina Statica; being the Aphorisms of *Sanctorius*, translated into English; with large Explanations. To which is added, Dr. Keill's *Medicina Statica Britannica*, with comparative Remarks and Explanations. As also *Medico-Physical* Essays on Agues, Fevers, an Elastick Fibre, the Gout, the Leprosy, King's-Evil and Venereal Diseases. The Third Edition, by the same Author, in 8vo.

Loimologia: Or, an historical Account of the Plague in London in 1665. with precautionary Directions against the like Contagion. By *Nathaniel Hodges*, M.D. and Fellow of the College of Physicians, who resided in the City all that Time. To which is added, an Essay on the different Causes of Pestilential Diseases, and how they become Contagious; with Remarks on the Infection now in France, and the most probable Means to prevent its spreading here. By the same Author. The Third Edition, with large Additions. 8vo.

Dr. *Quincy's* Answer to Dr. *Woodward's* State of Physic and Diseases.

A Mechanical Account of Fevers. By *Laurentius Bellini*, M.D. and Professor of Physick in the University of Pisa. Done into English, with a large Explanatory Introduction, helping the better to understand some other Writings also of the same Author. 8vo.

Theatrum Tabidorum: Or, the Nature and Cure of Consumptions, whether a Phtisick, an Atrophy, or an Hectick; with preliminary Exercitations. By *Christopher Bennet*, M.D. and Fellow of the College of Physicians. Translated into English 8vo.

Physico-Chirurgical Treatises of the Gout, King's-Evil, and the Lues Venerea; giving a rational Account of the Origin of those Distempers; as likewise the Origin of their Causes, their Increase, Progress and Symptoms; as also of their Methods of Cure, different from what hath been hitherto proposed; with their Differences, Diagnosticks, and Prognosticks, and an Account of a particular Medicine, which in a little time removes the Pain of the Gout, which we have not kept as a Secret, but communicated for the Use of the Publick. To which is added, an Essay of the Reason for intermitting Fevers, and the Effects of the *Cortex Peru*; with a Method of Cure, by that as well as other Medicines. By *Richard Boulton*, late of *Brasen-Nose* College, Oxon. 8vo.

Microtechnæ: Or, a Methodical Introduction to the Art of Chirurgery; in which every Branch thereof is handled in a most natural, compendious, and perspicuous Manner; and constant References are made under each Head, to the best Authors who have treated on that Subject more largely; together with a Critique on the most eminent Writers in the Art, written in Latin by *Johannes Van Horn*, Professor of Anatomy and Chirurgery in the University of Leyden. Translated with Additions. by *Henry Baner*, Surgeon. 12mo.

96h

A NEW
M E T H O D
OF
C H E M I S T R Y ;

INCLUDING THE
THEORY and PRACTICE of that *Art* :
Laid down on MECHANICAL PRINCIPLES,
and accommodated to the *USES* of *LIFE*.

The whole making
A CLEAR and RATIONAL SYSTEM of
C H E M I C A L P H I L O S O P H Y.

To which is prefix'd
A CRITICAL HISTORY of *CHEMISTRY* and *CHEMISTS*,
From the Origin of the Art to the present Time.

Written by the very Learned
H. B O E R H A A V E,
Professor of *Chemistry*, *Botany*, and *Medicine* in the University of
Leyden, and Member of the Royal Academy of Sciences at *Paris*.

Translated from the Printed Edition, collated with the best
MANUSCRIPT COPIES.

By P. SHAW, M. D. and E. CHAMBERS, Gent.

With additional Notes and Sculptures,

And a COPIOUS INDEX to the Whole.

L O N D O N :

Printed for J. OSBORN and T. LONGMAN, at the *Ship* in
Pater-noster-Row. M.DCC.XXVII.

5

METHOD
OF CHEMISTRY

THEORY AND PRACTICE OF CHEMISTRY
AND DOWN ON MECHANICAL PRINCIPLES
AND ASSOCIATED TO THE USES OF LIFE
A CLEAR AND RATIONAL SYSTEM OF
CHEMICAL TECHNOLOGY
A CRITICAL HISTORY OF
FROM THE ORIGIN
AND CHEMISTS



H. W. ROSE
LONDON
THE UNIVERSITY OF
LONDON
THE ROYAL SOCIETY
OF LONDON
THE ROYAL SOCIETY
OF LONDON

THE ROYAL SOCIETY
OF LONDON
THE ROYAL SOCIETY
OF LONDON
THE ROYAL SOCIETY
OF LONDON

Advertisement.

SOME of the advantages of this work are briefly touch'd upon by the author, in his own preface; to which we shall forbear making any addition, how strongly soever we may be tempted thereto. We apprehend it safer to be sparing on that point, and rather leave the reader to discover them by their own light, than by an officious zeal forestall his curiosity, or prepossess him with beauties, which may be only such to our selves.

We are, perhaps, too nearly concern'd in the cause, to be admitted to speak of it without suspicion: for tho' it be only a sort of secondary credit we pretend to from it; yet there are some circumstances, which, for ought we know, may entitle us to the whole. 'Tis no secret, that the learned author has abandon'd this his latest offspring: tho' it was known he had gone with it many years; and great preparations were made for the delivery; yet it at last came forth before its time. The truth is, he could not prevail on himself to let it go: his excessive scrupulousness was not contented with a nonum prematur in annum twice over; and he had in all probability with-held it half an age longer, had it not arrived at strength and maturity enough to make its escape, it self. It was no sooner in the world, than, with all the disadvantages so irregular a birth had occasioned, it found its admirers: unlick'd, uncompos'd, unswaddled as it was, rudis indigestaque moles, yet there every where appear'd the sensible traces of an exquisite form, which nothing could overpower or efface.

This mov'd us to take the unhappy fugitive under our care; and supply, in some measure, the wanted office of the natural parent. What we have done for it, let others say; the most transient view of its former, compared with its present, state, will

Advertisement.

will easily shew it. In short, we adjusted and composed its dislocated parts; pared off the redundant ones; dress'd it a-new; nay, and adorn'd and enrich'd it; with a concern and affection rarely shewn to the productions of other people.

If any misconstrue our intentions herein; and charge us with a crime in attempting to rescue a valuable work, just ready to be sacrificed to the cruel delicacy of its author; and making an offering of it to the public, which was in danger of being defrauded of its due; we have nothing to reply, but that we — count their censure praise.

*This does but put us on a footing with some of the greatest and most deserving persons of many ages, who are on record for the same crime: if their names were rehearsed, Boerhaave * himself would be found of the number.*

* — Intellexeram, virum celeberrimum
haud ita facilem in emittenda sua in publicum, ideoque, si rogaretur, forte intercessurum. Ergo ne sic quidem, ut apparent alienâ evulgatæ curâ, displicituras vobis crediderim! Satiùs quippe arbitror,

opus utile juvare publica commoda, quam idem inter manus nimis atque anxie elegantis auctoris in omne ævum premi. Immodica sanè elaboratissimæ perfectionis studia optima quæque eripere publico.
Prefat. ad Serm. Seb. Vaillant de Struch. Floram.



The AUTHOR'S

P R E F A C E.

WHAT we are now entering upon, is a *Body of Chemistry*; deliver'd in clear terms; founded on sure Principles; and rais'd with undeniable experiments: In the course whereof, will abundantly appear the vast extent and importance of the art; and the great share it has, not only in medicine, but in all the parts of natural philosophy, and the mechanic arts. To accomplish this the more distinctly, and fully, we divide the whole into three parts, *Historical, Theoretical, and Practical*.

In the *first*, We shall shew, from the most antient, and authentic remains of *history*, what the art originally was; in what country, at what time, and by what persons invented, cultivated, and improved; how it degenerated, and was corrupted; how, and by what hands it was again purged, and restored; and how, thro' various ages, nations, and authors, it is at length transmitted to us. A history of this kind, tho' not absolutely necessary to the knowledge of chemistry, would, yet, be wanting to the curiosity of such as apply 'emselves thereto; as nothing uses to be more interesting to an artist, than to know the rise and fate of his art. This part we chuse to call by the name *Prolegomena*.

Secondly, We shall lay down the *axioms*, or assumptions of chemistry; *i. e.* all the general truths which the particular experiments of chemists have hitherto demonstrated. These are what we assume, or take for granted; and the whole body of such universal truths, collected from all the particular ones, makes what we call the *Theory of Chemistry*.

For

The AUTHOR'S Preface.

For chemistry is no science form'd *à priori*; 'tis no production of the human mind, framed by reasoning and deduction: It took its rise from a number of experiments casually made, without any expectation of what follow'd; and was only reduced into an art or system, by collecting and comparing the effects of such unpremeditated experiments, and observing the uniform tendency thereof. So far, then, as a number of experiments agree to establish any undoubted truth; so far they may be consider'd as constituting the theory of chemistry.

Now, such doctrine or theory is necessary to be premised to every art; and something equivalent hereto, is practised by every artizan: To instruct his disciples how to proceed orderly to the exercise of their art, he must lay them down the general truths or rules thereof. This may bear a little further illustration: All the experiments ever yet made, agree in this, That no chemical operation is perform'd without fluids; or that all chemical alteration is effected by means of some fluid: This, therefore, may be laid down as an universal truth, or axiom of chemistry.

Again, from infinite observations and experiments, it is found, that there is no fluid without fire; or that all fluid bodies, as water, oil, spirits, &c. entirely devoid of fire, become solids: consequently, if there were no fire, all the bodies in nature would fix into one rigid, consistent mass. Whence it easily follows, that all operations are perform'd by means of fire: which is another universal truth.

Again, from a thousand experiments, made by as many persons, in different places, it appears that there is not one grain of fix'd salt in any part of an animal body: So that this, too, may be assumed as an axiom.

From the instances here brought, it easily appears, that the truths of chemistry are none of 'em deduced *à priori*, from any abstract contemplations of the mind; but collected *à posteriori*, from innumerable experiments. And such truths may be consider'd, either as universal phenomena, or canons of chemistry, or as combinations or systems of the particular truths collected, and digested therein.

Now, it were impossible to teach the practice of chemistry, to the purpose, without some such previous theory. To give a novice a parcel of wormwood, for instance, and bid him distil, and get the spirit from it, would be in vain, unless he knew before-hand, this general truth, or axiom, That all plants, exposed to a gentle heat,

heat, evaporate their most subtile volatile part; and that this part, caught, and collected in a close vessel, is the spirit required. We esteem it, therefore, incumbent on us, before we proceed to the practice, to give a candid and ample detail of these general axioms, or assumptions.

Thirdly, We shall exhibit a course of chemical *operations*, or the actual changes producible in bodies, by attending to the laws, or axioms of the art. This part we have been conversant in now upwards of twenty years; and from the first, have found it necessary to go in a *new method*, differing very widely from what has been observ'd by the most celebrated chemists of *Europe* in their courses, and lectures. All these authors we have been at the pains of reading over; and have every where found 'em as abrupt, and disorderly, as they are scanty and defective: a tumultuary mass of pharmaceutical processes, without any certain design or coherence, is all they afford. The best of 'em is Monsieur *Lemery*, whose performance has gone thro' I don't know how many editions, in various languages; and yet nothing could be worse concerted for such as study the art: He begins with the very hardest part, metals; a great number of his processes are merely calculated for the preparing of remedies; and his view, throughout the whole, is rather to furnish the shops with medicines, than to instruct his readers in the knowledge of chemistry. But how hard and unjust is this on poor chemistry! To make an art a drudge to physic, which, in reality, is the principal part of all philosophy!

The processes of chemistry, 'tis true, are almost infinite; and it were impossible to exhibit all that the chemists have hitherto invented, in the course of a man's life.

The method we pursue, then, is to reduce all the most useful, and instructive ones, to certain classes; to begin with the most simple, and easy of these; and lay them down in such a manner, as to serve for a basis to the next; and those, in their turn, to others; till we arrive at the most difficult, and complicated processes, by an easy, and gradual ascent: the second operation being never required to the understanding of the first; nor the third to the second; but the first always necessary to the second, and that again to the third: so that there will be no occasion for ever repeating the same operation. Two hundred processes, conducted after this manner, will set all the fundamentals of the art to view; and a few canons, or general rules, subjoin'd to each process, will open the way for all
the

The AUTHOR'S Preface.

the other numberless processes to be perform'd: So that at the same time that our reader has only the marrow of the art presented him, he is really put in possession of the whole bulk thereof.

In each process our Method shall be, 1^o, To exhibit the object. 2^o, To explain the operation. 3^o, To shew the effects of the change therein. The genuine virtues, and medicinal properties of each production shall be added; such, as we have approv'd them by abundant experience: And these we promise to describe in the most severe, and scrupulous manner; far from any taint of the wild flights, and extravagancies usual among the chemists.

'Tis certain, medicine has suffer'd extremely from this quarter; every chemist affixing virtues to his preparations at random. Thus, salts drawn from the ashes of plants, having, on some occasions, been found of service in tertians and quartans; immediately an anti-febrific virtue is assign'd thereto; and they must be administer'd, in all fevers, indifferently: when, 'tis certain, that in inflammatory fevers they promote the disease, and hasten death. Indeed, the chemists should always be suspected, when they boast of general virtues in their preparations: There is nothing so precarious, and ill-warranted as such pretences; nor can a man soberly say there is any such thing as one preparation always effectual in any disease; no universal febrifuge, for instance, against all fevers; nor general lithontriptic, in all cases of the stone.



A TABLE of CONTENTS, drawn up Analytically.

Of the Prolegomena, or History of Chemistry.

O RIGIN and Etymology of the name
Chemistry. p. 1—5
Antiquity of the art, and whence
deduced. 5—7
What part of it was first invented;
where first practised, and by whom. 7—9
Particular inquiry into the *Æra* of Al-
chemy; and whether it was known
among the antients. 9—13
The Progress of Chemistry under the sever-
al authors and improvers thereof,
from *Zosimus* to our time; with their
respective discoveries, principles, and
dogma's; their writings, and the
characters thereof. 13, & seq.
Zosimus, and other *Greeks*, 14. *Geber*,
ib. *Albertus Magnus*, 15. *Roger Ba-*
con, 15. *Raymond Lully*, 18. *Arnoldus*
de Villa nova, 19. *Johannes de Rupe*

Sciffa, 20. *G. Ripley*, ib. *Jo. & Jf.*
Hollandus, ib. *Basil Valentine*, 21. *Pa-*
racelsus, 22—30. And *Van Helmont*;
with whom the progress ended. 30
—36
The principal chemical authors which have
since appear'd, reduced to classes, ac-
cording to their several subjects, or
the branches they have treated. 37
Writers of Courses or Processes—*Baguinus*,
Crollius, *Glafer*, *Lemery*, *Barchausen*, *Le*
Moss. 38—39
Metallurgic writers—*Agricola*, *Ercher*,
Glauber, &c. 40—42
Alchemists—*Van Zuchten*, *Canticoglio*,
Agricola, *Philalethes*, *Pantaleo*, *Artepbius*,
Dee, and *Kelley*. 42—45
Chemists who applied the art to phi-
losophy and medicine;—*Boyle*, *Tache-*
nus, *Bohnus*, *Homborg*, &c. 46—50

Of the Theory of Chemistry.

T HE nature and idea of chemistry. 51, 52.
Its Object, Body, divided into classes or
kingdoms. 52, 53.
Viz. FOSSILS—Their definition, prop-
erties, and sub-division. 54
Into METALS—The natural history
thereof—Their generation, and
the reason of their characters,
&c. 55, 56
Particularly Gold—Its several dis-
tinguishing properties—Its
truth, purity, &c. how tried,

56—68—Where, and in what
form it is found, 69, 70.—How
separated from the ore, purified,
&c. 70, 71
Mercury—Its sensible properties,
&c. 71—76—The form it is
found in, 76, 77.—Manner of
separating it. 77
Lead—Its several properties—
How found and separated—Its
use in the purifying the nobler
metals, &c. 77—82

The CONTENTS.

<i>Silver</i> —Its properties, separation, purification, &c.	86, 87	<i>oker, &c.</i> and the natural history of each.	136—138
<i>Copper</i> —The divers properties thereof; with the method of separating it.	88—90	<i>Glass</i> —What class of bodies it belongs to—Its properties, ingredients, method of making it, &c.	138, 139
<i>Iron</i> —Its properties, where and how found, separated, &c.	91—95	Common principles of fossils.	139—141
<i> Tin</i> —Its properties, separation, purification, &c.	96—98	VEGETABLES —Their nature and definition—Structure—Parts—Vessels—Manner of their growth, or nutrition—Circulation—Generation—Perpendicular ascent, &c.	142—149
<i>Corollaries</i> concerning the common nature of metals; their principles and composition; and whether transmutable.	99—105	Their Juices—Six kinds or classes thereof, belonging to the different parts, viz. the root, leaves, flowers, fruit, seed, bark, &c.—The several species of each class; as wax, manna, oil, honey, balm, pitch, resins, colophony, gums, chyle and blood; the natural history, office, &c. of each.	149—161
SALTS —Their definition and general characters—The several species thereof; viz. sea-salt, rock-salt, salt-petre, sul-ammoniac, borax, alum, &c.—The natural history, properties, preparations, purifications, &c.	105—113	Their principles, and wherein they differ from fossils, &c.—With a distribution of the kingdom into kinds.	162, 162
Their elements or common principles.	113	ANIMALS —Their definition, and by what Characters distinguish'd from vegetables—Their solid and fluid parts—Principles, &c.	162—169
STONES —Their nature and distinguishing characters.	114	Its Operations —Their nature, means, and effect—To be accounted for on principles of mechanics—Their several kinds, as calcination, sublimation, fermentation, digestion, &c. reduced to two—With a rationale of the nature of their effects on bodies, and of the elements or principles procur'd hereby.	170—188
Precious Stones, their nature, kinds, criterions, composition, uses, &c.	114—117	Its Productions or Effects —Reduced to four kinds, viz. magisteries, extracts, elixirs, and clysters.	189, 190
Vulgar stones.	118	Its End, and Uses, specified.	191
Origin and formation of stones.	118—121	In natural philosophy.	192, 193
EARTHS —Their definition, qualities, kinds, &c.	122—124	In medicine—The several branches thereof; as physiology, pathology, semeiotics, hygiene, and therapeutics.	193—199
SULPHURS —Nature and characters thereof.	125	In the mechanical arts—As Painting, Enamelling—Staining, and making glass—Dying—Making artificial gems—Minerology—Metallurgia—Military art—Pyrotechnia—Natural magic—Culinary art—Making Wines—Brewing, &c.	199—215
Solid sulphurs—The several kinds thereof, as sulphur vivum, arsenic, orpiment, bitumen, asphaltum, amber, ambergrease, &c. with the natural history of each.	125		
Liquid Sulphurs—The nature, properties, &c. of each kind thereof; as naphtha, petrol, oleum terræ, &c.	128—130		
SEMIMETALS —Nature, definition, and division thereof.	131, 132		
Of a metal and sulphur—The kinds thereof, as antimony, cinabar, marcassite, bismuth, calamine, cobalt, pyrites, &c. their natural history, &c.	132—134		
Of a metal and salt—Kinds, properties, &c. thereof; as vitriols, &c.	134—136		
Of a metal and earth—Kinds thereof, as the Armenian stone, lapis bematites, load-stone, atites,			

The CONTENTS.

xi

In alchemy—The nature, object, views, principles, &c. thereof. 215—218

Its Instruments—The general nature, and definition thereof—Reduced to six kinds. 218

Viz. FIRE—The natural history thereof—Its origin, and whether producible—Its kinds, properties and powers; *viz.* heat, light, colour, &c.—Its effects in producing the phenomena of the grand world—Itself always latent, and only discoverable by being collected. 218—238

Two ways of collecting and making it sensible. 238

By a Luminary—As the Sun: Its nature; and whence its effects; its rays, how managed catoptrically and dioptrically; and how influenced by the clouds, mountains, &c. 238—248

By Attrition—Its nature, and laws. 249—250

Vulgar Fire—What it is—By what means excited and collected, *viz.* by putrefaction, phosphorus, the mixture of liquors, and even of solid matters. 258—262 & 270

Pabulum of fire—the nature, and office thereof—Oil the only proper pabulum, or inflammable part in all bodies. 262—265

Fuel—How acted on, and affected by fire—The several sorts thereof—as charcoal, turf, peat, pitcoal, dungs, &c. their history, qualities, with the differences they make in the fire. 265—268

Effects of fire different, according to the place, fuel, manner of blowing, &c. with the office of the air in sustaining fire. 269—271

Direction and management of fire for the purposes of chemistry. 271, 272

The various degrees made use of; with their standards, or measures. 272, 273

These degrees, how changed—*viz.* by the quantity of fuel, the distance, the air, and the solidity of a medium, or body interposed, by way of bath. 273—275

The chemists fire makes an alteration in the nature of its subjects; and its effects of a contrary kind, according to the degree, circumstances, &c. 275—276

AIR—Its nature and constituent parts. 277

Fire contain'd in it: and its fluidity, &c. owing thereto. 276—279

Exhalations of all kinds, in the air, whereby it becomes a chaos or universal conflux of all bodies, fossil, vegetable, and animal—Diversities of the air in respect of places, seasons, regions, &c. how owing hereto. 279—290

Air properly so call'd—Its properties and powers; the structure of its particles, how changed and affected by heat, cold, &c. 290—295

Its effects in determining the Actions of bodies upon one another; mixing bodies together; agitating their particles; binding up the vessels of animals; giving the sensations of taste and smell; producing flame, motion, solution, vegetation, putrefaction, &c. 295—301

Air, consider'd in its quality of a chaos, an universal dissolvent—The differences therein, and what effects they produce in operations and experiments. 301—304

WATER—Its nature, and form. 305—306
An universal Instrument, contain'd in all bodies and places. 306

Opinions of philosophers concerning it; whether it be the matter whereof all bodies are composed; and whether naturally fresh or salt. 306—309, & 319

Its fluidity, whether natural to it. 309, 310

Kinds thereof, *viz.* rain, spring, river, mineral, &c. waters—Their qualities, degrees of purity, &c. with the method of trying the freshness of water, and making salt water fresh. 310—312

Whether it be convertible into earth. 313

Its subtle and penetrative nature beyond that of the air. 314—315

All the firmness and stability in nature owing to it. 315, 316

- Un-elastic, and incompressible. 317, 318
 Properties of its particles. 318, 319
 Void both of taste and smell. 319
 Its solutive power, to what bodies extended, and what not. 320, 321
 With salts, shoots into crystals. 321
 Is the great instrument of all putrefaction, fermentation, and effervescency. 321, 322
 Its use in making separations of heterogeneous mixts, distillations, volatilizations, &c. 323
 And in baths, for the direction of fire. 324
- EARTH**—Its definition and character. 325
 How obtain'd from all bodies, vegetable, animal, and fossil. 321—328
 Its use in natural bodies, and in operations of chemistry. 329—331
- Of MENSTRUUMS**—Their nature, and definition. 332
 Two kinds thereof. 333
 Solid or dry menstrua; as metals, sulphurs, salts, &c.—which act by trituration, humectation and heat. 332—336
 Liquid menstrua—Either aqueous, saline, acid, alkaline, spirituous, fixed alkalies, or compounds thereof. 336—342
 Manner of their action; with the conditions requisite thereto; the laws observ'd therein, and the consequences deducible therefrom. 348—350
 Rules for the management, and application of menstrua, preparing the solvents, and determining the proper solvents. 350—356
 The action of neutral salts, menstrua procured by fermentation, and other anomalous ones; as native turpentine, and white or yolk of an egg, gall, honey, &c. 356—359
- Corollaries from the doctrine of menstrua.** 359—362
 Of the *alcahest*, or universal menstruum—Its idea and office. 362, 363
 Origin of the name, with the synonymia, or other terms of the same import. 363—366
 Origin and properties ascribed to the *alcahest*. 366—370
 The author's opinion concerning it. 370—372
- INSTRUMENTS**, properly so call'd—372
 What, and their kinds. 372
Viz. Chemical vessels—defined—divided into metalline, earthen, and those of glass; into cones and cylinders. 372—375
 Cucurbit—Its figure and use. 375.
 —Matrass, or circulatory vessel. *ib.*—Retort. *ib.*—Receiver. *ib.*
 Long neck. *ib.*—Alembic. 376
 Pelican, &c. *ib.*
 Chemical furnaces—Their definition, office, and parts—Their perfection, wherein it consists. 377, 378
 Arhanor, or Furnus pigri Henrici—Its figure, structure, &c. 378, 379.
 —Digesting furnace. *ib.*—Wooden digesting furnace. *ib.*—Simple furnace for the cold still. *ib.*—Common furnace for the hot still, or copper alembic. 380—*Balneum Marie*, or bath furnace. *ib.*
 Sand furnace. *ib.*—Wind furnace, melting furnace, reverberatory furnace, &c. *ib.*—Parabolic furnace. 381
- LUTES**—Their definition and office. *ib.*—The common Lute, its composition. *ib.*—Philosophical lute, or *lutum sapientie*; preparation thereof, 381, 382—For coating retorts. 282, 283

The CONTENTS.

xiii

Of the Practice of Chemistry.

CHIMICAL OPERATIONS, or Processes defined. 1, 2
How render'd useful and instructive. 2, 3
Fundamentals of the art. 4—12
A vegetable subject to be first treated in a course of chemistry, and in what manner. 4—7
VEGETABLES, their parts, vessels, and juices. 7—9
Atmospheres or exhalations. 9—12, 18, 19
How best obtainable from chemistry. 12, 15—and from what subjects. 17, 18
Nature of the waters they afford by gentle heat. 16
How best to preserve them. *ibid.*
How affected by heat. 18
Cause of their taste and odour. *ibid.*
How treated to advantage by infusion and decoction. 20, 21
Ultimate effects of boiling water thereon. 22—24
How prepared into *Robs*, *Defruta*, gellies, and extracts. 25—28
Reduced to insipid *asbes*. 29, 30
Their composition. 30, 31—33
Whence their specific virtues. 31
Reduced to saline *asbes*. 32, 33
Their essential salts how obtainable. 33—35, 36—41
Their nature, species and differences. 34—36
Their medicated salts, how procured, their origin nature, design, difference, medicinal virtues and uses. 37—40
Their fix'd salts, how prepared, and whence, together with their characters. 42, 43
Their fix'd alkali, how prepared; its nature, properties, virtues and uses. 43—48
Its purification, method of increasing its strength, its virtues, uses, &c. 48—51
Whence its fixedness, whence produced and what it really is. 52, 53
Their different species of salts. 53—55
Their distill'd waters, how and whence usually obtain'd, with their virtues, uses, &c. 57—59
The method of cohobating them, with

the reason and uses thereof. 61—64
Their distill'd waters by fermentation, how best obtain'd, with their virtues, uses, &c. 65—68
Their distill'd waters per descensum, with the virtues, and uses thereof. 68, 69
Their oils defined, their nature, seat, use, &c. 68—62
How best obtain'd by expression. 71—73
How by emulsion. 73—75
How by coction. 75, 76
How by distillation, with their virtues, use, &c. 76—86
How procured, native, from spices. 86, 87
How procured, essential, from barks. 88, 89
How from woods. 89—91
How per descensum. 92, 93
How separated from the other parts of plants. 99, 100
The analysis of the acid species, when dry, how to be conducted, with the uses thereof. 94—96
Of the alkaline species, with the uses, and virtues of the productions. 97, 98
Their balsams how analyzed, with the uses thereof. 102—105
Analysis of wax, its nature, with the virtues and uses of the productions. 105, 106
Eleosacchara, or sugar-balsams how prepared, with their nature and uses. 107, 108
Medicated liquors afforded by 'em, with their virtues and uses. 109, 110
Sweet-scented, or apoplectic balsams, how obtained therefrom, how varied, and applied. 110—112
Afford no inflammable spirit without fermentation. 113, 114
Fermentation defined, and its phaenomena and doctrine delivered. 115—123
Its requisites. 120—123
Fermentable Bodies defined and classed. 117—119
Ferments what, their several kinds. 117—120—123
Heterogeneous ferments. 122, 123
Diffe.

- Different ways of fermenting suited to different subjects. 117—119
—130
- Bread-corn, pulse, and nuts how fermented and brewed. 123—129
- Summer-fruits, succulent plants, and expressed or native juices, how fermented and turn'd to wine. 118, 119—127
- Phænomena of fermentation, with its physical effects. 128—131
- How promoted and restrained. 131, 132
- Inflammable spirits how procured, with the natures, virtues, and uses thereof. 132—135
- Rectified and raised to alcohol, *per se*, with its nature, uses, virtues &c. 136—139
- How to prepare this alcohol with fix'd alkali; its nature, uses, &c. 139—141
- Vinegar how procured, the laws wherein the operation proceeds, how forwarded, restrained, &c. with the uses and virtues of the production. 142—147
- Its analysis, with the doctrine it affords, with the virtues and uses of the productions. 147—149
- Its rectification *per se*, and with metals. 149—152
- Tartar, how produced; its nature virtues, uses, &c. 152—155
- Its analysis, with the uses of the productions obtain'd thereby. 154—157
- Tinctures thereof, how made with spirit of wine, from resinous subjects; with their uses, &c. 157—160
- How made with alcohol *per se*; and how with alcohol and fix'd alkali, from subjects of a strong texture. 160—164
- Cathartic potions how made from resinous tinctures. 164
- Resins how obtain'd; with the nature and uses thereof. 165—167
- Essential extracts, how made, with the uses thereof. 167—169
- Quintessences how procured, how from the resins of *Asia*, and how in a dry form, their virtues, uses, &c. 169—173
- Medicated aromatic spirits, both simple and compound, how prepared, with an account of their nature, uses, &c. 173—176
- Soaps, how made—by boiling—by digestion—with their virtues and uses, and how united together. 176—181
- Tartar, the preparations thereof—*viz.*
soluble or tartarized tartar, how made; the nature and medicinal virtues thereof. 181—183
- Manner of regenerating it, or preparing the foliated earth of tartar, with its chemical and medicinal uses. 183—186
- Manner of dissolving tartarized tartar, or making a tincture thereof. 188
- Manner of dissolving regenerated tartar, and making a tincture with alcohol; with the uses thereof. 161
- Harvey's tincture of salt of tartar, with spirit of wine; its virtues and uses, &c. 162
- Helmont's tincture of salt of tartar, with alcohol. 163
- Elixirs, how prepared from them with vinegar, how with fix'd alkali and distill'd water, how with alcohol and fix'd alkali, how with rectified spirit of wine and soluble tartar, and how with alcohol and regenerated tartar. 166—172
- Amber, its analysis, to determine its nature. 173, 174
- The phenomena, nature, uses and effects of vegetable putrefaction. 175—177
- Axioms, relating to ANIMALS, borrow'd from medicine. 179
- Milk, shewn to be neither acid nor alkaline. 182, 183
- Turns acid by digestion. 183
- Coagulates with acids. 183
- Turns red by boiling with alkalies. 184
- Urine, shewn to be neither alkaline nor acid. 186—188
- Its parts, upon the analysis, neither acid nor alkaline. 188, 189
- Made to yield a volatile, alkaline salt. 189, 190
- Turn'd of an alkaline nature, with fix'd alkali. 190, 191
- Recents, made to afford a fiery, but not alkaline spirit. 191
- Will yield an essential salt. 193
- Becomes alkaline by digestion 194, 195
- Its analysis, after digestion, with the doctrine it leads to. 195, 198
- Sil-Ammoniac, its production from urine, sea-salt and soot. 198, 200
- Is neither acid nor alkali. 200
- How

The CONTENTS.

xv

How purified, turn'd to a fiery, volatile spirit, and alkaline salt by fix'd alkali.	202, 203	Its solution in fix'd and volatile alkalies.	254, 255
Sea-salt regenerated from it.	203, 204	Its Tincture in alcohol with fix'd alkali.	256
White of Eggs, neither alkaline nor acid.	206	Its Syrup.	257
Dissolves, when fresh, with a gentle heat, but concretes with a strong one.	206, 207	Its balsams.	258—260
Is concretescible in alcohol.	207, 208	Its soap.	260
Its distill'd water neither acid nor alkaline.	208	Its generation from oil of vitriol and oil of turpentine, and from oil of vitriol and alcohol.	261, 262
Its analysis by a strong heat.	208, 209	<i>Lac sulphuris.</i>	263
Will putrefy and turn alkaline by digestion.	209	<i>Iron</i> , its vitriol, how prepared.	264, 265
<i>Serum of the Blood</i> , neither acid nor alkali.	210, 211	Its tincture, or potable vitriol.	265, 266
Putrefies by digestion.	211, 212	Reduced to a <i>calx</i> or <i>crocus</i> .	266, 267
Concretes with a greater heat.	212, 213	Run <i>per deliquium</i> .	267, 268
Coagulates with alcohol.	213	Its golden tincture.	268, 269
Its water by gentle distillation.	214	Its solution in <i>Rhenish</i> wine.	269
Its analysis by a strong heat, after inspissation.	215, 216	Its solution in vinegar.	270
<i>Animal Solids</i> , consist of the same principles as the animal fluids.	217, 218	Its sublimation with <i>Sal Armoniac</i> .	270, 271
<i>Animal Principles</i> , how purified.	220—225	Its calcination with sulphur.	272
Animal, alkaline, spirits coagulated with alcohol.	225, 226	<i>Lead</i> , its solution by the fumes of vinegar, or conversion into ceruse.	272, 273
<i>Sal volatile oleosum</i> , simple, compound, specific and extemporaneous, how produced.	226—229	Its calcination, or reduction to red lead.	274, 275
<i>Blood</i> , the phenomena it affords by mixing with salts and oils.	230—232	Its solution in distill'd vinegar.	275, 276
FOSSILS, their structure and analysis.	233	Its vitriol or sugar, how procured with vinegar, or small <i>aqua fortis</i> .	276—278
<i>Nitre</i> , its origin; the artificial method of procuring, purifying and converting it to fix'd alkali, with tartar and a glowing coal.	233—237	Its balsam with oil of turpentine.	278
How turn'd into <i>sal prunella</i> , and how into <i>sal polychrestum</i> with sulphur.	238, 239	Its conversion into glass.	278, 279
Its spirit by distillation with bole.	239, 240	<i>Silver</i> , its solution and crystallization in <i>aqua fortis</i> .	279—281
With oil of vitriol.	241, 242	Its vitriol.	281, 282
Its dulcified spirit.	242	Its purging vitriol.	283
Its regeneration by means of fix'd alkali and <i>sal-ammoniac</i> .	243, 244	Its precipitation and reduction to <i>luna cornea</i> .	283, 284
Impregnated with its own spirit.	244	Its reduction to metal, from its inflammable vitriol or nitre.	284
The method of producing vegetative nitre.	244, 245	<i>Tin</i> , its calcination, solution, and crystallization.	285
Sea-salt; its spirit.	246, 247	<i>Copper</i> , its solution and crystallization with distill'd vinegar.	285, 286
<i>Sal mirabile</i> .	247, 248	Its solution and crystallization with the spirit of <i>Sal ammoniac</i> .	286, 287
Its regeneration.	249	<i>Quick-silver</i> , its solution and crystallization in <i>Aqua fortis</i> .	288—290
The extemporaneous production of <i>Sal-ammoniac</i> with its spirit.	250	Its white and red precipitate.	290—292
<i>Sulphur</i> , its sublimation into flowers.	252	Its solution in oil of vitriol.	292
Its analysis	253, 254	Its fiery oil, when dissolved in oil of vitriol.	293
		How made into <i>Turpethum mixerale</i> .	294
			295

The CONTENTS.

Its reduction into <i>Aethiops mineral</i> with sulphur.	295	Conversion of its butter into oil.	316,
Its conversion into corrosive sublimate.	295	Precipitation of its butter into <i>Mercurius vitæ</i> .	317
Its preparation into cinnabar, with sulphur.	296	Preparation of bezoar mineral from its butter.	318
Its amalgamation with lead.	296, 297	Preparation of its cinnabar.	319
<i>Vitriol</i> , its analysis.	299	Its emetic flowers.	320
Preparation of <i>Tartarum vitriolatum</i> .	300, 301	Its fixed flowers, according to <i>Hellmont</i> .	321
Preparation of <i>Ens Veneris</i> , from its colcothar.	301, 302	Its purging flowers, according to <i>Hellmont</i> .	321, 322
<i>Antimony</i> , its solution in <i>Aqua regia</i> .	303	Solution, by what means, and with what bodies effected.	324
Its sulphur, how procured.	303, 304	Codgulation, by what means, and with what bodies produced.	324, 325
Its purification by simple fusion.	304	Precipitation, what, and how procured.	325, 326
By flux-powders.	305, 306	<i>Effervescence</i> , what; wherein it obtains, how produced, its different kinds, &c.	327, 328
With salts and metals.	306—308	<i>Odours</i> , where seated in the subject.	328,
Its golden sulphur.	308, 309		329
Its <i>crocus</i> , or liver.	309, 310	<i>Tastes</i> , whence in bodies.	329, 330
A mild emetic from it.	310, 311	<i>Colours</i> , their nature, production, mutability, &c.	330, 335
Diaphoretic antimony, with nitre.	311,		
	312		
Common diaphoretic antimony.	312,		
	313		
Its diaphoretic nitre.	313		
Its fixed sulphur.	314		
Its butter, or icy oil.	314—316		



P A R T I.

P R O L E G O M E N A,

OR THE

History of Chemistry.

THE first thing that occurs in our undertaking, is the word *chemiftry*, which in *Greek* should be wrote $\chi\eta\mu\iota\alpha$, and in *Latin* *chemiftry*, and *Englifh*, *chemia* and *chemiftry*, not as ufual, *chymia* and *chy-miftry*.

The first author in whom the word is found, is *Plutarch*, who lived under the emperors *Domitian*, *Nerva*, and *Trajan*. That philosopher, in his treatife of *Ifis* and *Ofiris*, takes occafion to obferve, That *Egypt**, in the fared dialect of the Country, was call'd by the fame name as the black of the eye, viz. $\chi\eta\mu\iota\alpha$, *chemia*: by which he feems to intimate, that the word *chemia*, in the *Egyptian* language, fignified *black*; and that the country, *Egypt*, might take its denomination from the *blacknefs* of the foil.

But the etymology and grammatical fignification of the name is not fo eafily difpatched. The critics and antiquaries, among whom it has been a great fubject of enquiry, will not let it pafs without fome further difquifition: Inftead of *black*, fome will have it originally denote *fecret*, or *occult*; and derive it from the *Hebrew* *Chaman*, or *Haman*, a *mystery*, whose radix is *Cham*. And, accordingly, *Plutarch* obferves, that *Egypt*, in the fame fared dialect, is fometimes wrote in *Greek*, $\chi\alpha\mu\iota\alpha$ *Chamia*: whence the word is eafily deduced further from *Cham*, eldeft Son of *Noah*, by

* Αἰγυπτὸς ὡς τὸ μετὰ οφθαλμοῦ χημῖαν καλεῖται.

History of CHEMISTRY.

whom *Egypt* was first peopled after the deluge, and from whom, in the scripture-style, it is call'd the *land of Cham*, or *Chem*. Now, that *Chaman*, or *Haman*, properly signifies *secret*, appears from the same *Plutarch*, who, mentioning an antient author, named *Menethes Sibonita*, who had asserted, that *Ammon*, and *Hammon*, were us'd to denote the god of *Egypt*; *Plutarch* * takes this occasion to observe, that in the *Egyptian* language, any thing secret or occult, was call'd by the same name *αμμων*, *Hammon*. Add, that *Hecataeus Abderita* notes *Ammon* to have been a common term of invocation, whereby the *Egyptians* call'd one another when out of the way, or not to be found; and hints, that it had no peculiar relation to their great god, which was the universe, otherwise than as he was *secret*, and invisible, and was hereby call'd to manifest himself. Lastly, the learned *Bochart* keeping to the same sense of the word, chuses to derive it from the *Arabic*, *Chema*, or *Kema*, to *hide*; adding, that there is an *Arabic* book of secrets, call'd by the same name *Kemi*.

What we gather from the whole, is, that our art, chemistry, should appear to have been originally thus denominated, because not fit to be divulged to the populace, but treasured up as a religious secret.

Origin of the
art, chemistry.

Thus much for the origin, and literal use of the name: As to its technical use, we have no testimonies of so much antiquity. The first time *χημια* occurs, as denoting the Art we are speaking of, is in a *Greek* Manuscript of *Zozimus the Panopolitan*, preserv'd in the king's library at *Paris*. This author, whom they stile *Panopolitanus*, to distinguish him from the historian of his name, seems to have lived under the younger *Theodosius*, about 400 years after *Christ*, or at least near the beginning of the fifth century. He wrote several treatises, still extant in manuscript in the *French* king's library; from one of which, *Scaliger* has transcribed the following passage, in his notes on *Eusebius de preparat. evangel.* The sacred writings say, there are a kind of demons who abuse women. *Hermes* testifies as much: And all our learning, both open and occult, confirms the account. What the divine writings relate, is, that the angels, enflamed with the desire of women, instructed 'em in all the works and mysteries of nature: For which indiscretion they were excluded heaven, as having taught men things unfit for 'em to know. The same scriptures add, that from hence arose the giants. Now our first most antient tradition, call'd *χημια*, is on these very arts: The book they were contain'd in, was call'd by the same name; and hence the art itself was call'd *χημια*, *Chemia*.

The passage here refer'd to in the sacred writings, seems to be that in *Genesis*, where *Moses* calls the descendants of *Cain*, sons of men; and those of *Seth*, sons of god. And the same prophet adds, that the sons of God saw the daughters of men, went in unto them, and that giants thence arose. Which chimes in to a tittle with what is quoted by *Zozimus*.

This passage deserves to be well noted; as we shall hereafter have occasion to shew, that the posterity of *Cain* were skilful in chemistry. But

* Αμμωνα το κηρυγματον ειναι λεγεσθαι. De Isid. & Orig.

who this *Hermes* was, the historian alludes to, is hard to say; for none of his writings have survived to our age: that lately published in *Italy*, under the name of *Hermes Trismegistus*, being a manifest forgery.

It may be observed by the way, that the doctrine of dæmons here mentioned by *Zozimus*, is expressly asserted by *Democritus*, *Plato*, *Philo Judæus*,^{Doctrin of dæmons.} and other philosophers; who represent them as endow'd with a penetrating mind, and boundless knowledge; not confined to our ways of conceiving things relatively, but fitted to perceive them as they are in themselves; not incumbered with a solid body, like us; but a penetrable one, like air. *Zozimus*, who adopts the doctrine with a peculiar fondness, observes further, that, beside the intuitive knowledge of the dæmons, there was, even in the antediluvian world, a kind of human sciences acquir'd only by reason and experiments; adding, that they in whom that latter knowledge was alone found, were denominated the *sons of men*; and the former, the *sons of God*.

The same notion of dæmons prevails among many to this very day, under the name of spectres, or spirits, who roam about with their penetrable matter, capable of discovering themselves to the human mind, and even of possessing the same, after the manner as the soul does the body. Divers instances of the same belief might be given from the antient Jews, and the earliest Christians. Our Saviour himself was twice taken for a dæmon, or spirit, when he walk'd on the sea, and after his resurrection: to say nothing of the current opinion of the *Mahometans*, *Arabs*, and other *Asiatics* and *Africans*.

These dæmons too, of the antients, were supposed subject to human passions; they saw the daughters of men, and they loved them, and courted them in marriage; and, as an equivalent for their virginity, offer'd them a book, containing the whole body of their science. The dowry was accepted, and call'd *παραδοσιν θεων*, divine tradition; and this mysterious knowledge, *χημα*, *Chema*; sometimes *αποκαλυψις*, revelation; and by *Zozimus*, *την ιεραγν τεχνην*, the sacred art. *Philo Judæus* is full of these reveries; and from him *Zozimus*, in all likelihood, borrow'd half the incidents of the fable.

This *Chema*, or *Chemia*, *Zozimus* will have the same with the antient *Cabala* of the Jews; which perish'd, with all their antiquities, in the destruction of *Jerusalem*, excepting some fragments retrieved from the common ruin, and published in the *Talmud*. Those fragments are but few, and besides, intermix'd with a world of trumpery. But *Zozimus* residing in the emperor's court, had an opportunity of perusing many of the antient monuments then extant in those libraries, which have since been plunder'd by the *Saracens*, so that his account carries with it the greater authority.

From the whole, it may be pretty safely argued, that whereas *Zozimus* deduces the name, and the art, *χημα*, from the angels, and supposes 'em communicated by them to their mistresses; they must both be earlier than the flood: since the like intrigues related by *Moses*, are expressly refer'd to the antediluvian ages.

Origin of chemistry according to the mythologists.

* The poets, and fabulous writers, give us a somewhat different origin of the antient *Chemia*: *Phæbus*, who is the sun of the *Phenicians*, the *Ees*, or *Aasch*, or *Mitra* of the *Persians*, the *ωρ* or *oers* of the *Greeks*, *Magi*, and *Jews*; the *Horus*, or *Deus gentium* of the *Latins*; and the God of light and physic among most of them; is said to have fallen passionately in love with a beautiful nymph, named *Sibylla*. His divinity, we are told, at first met with some repulse, till upon offering to comply with whatever terms she could propose, she consented; and demanded, as the price of her favour, as many years as she could hold grains of sand in one hand, together with the *δωρ βυαν*, the heavenly wisdom, or divine *arcanum*; from whence the denomination *Sibylla* was derived. Which account, in the main, tallies well enough with that of *Zozimus*; for here, the son of a God, is in love with a maid, and reveals his father's secrets. And both relations may receive some light from the fable of *Prometheus's* stealing the heavenly fire; which seems to refer to the same event.

After *Zozimus*, *Chemia* became a common term among the *Greek* writers, in the sense 'tis now used. And if we hear nothing of it among the *Romans*, 'tis because, after the translation of the seat of empire to *Constantinople*, *Greek* becoming the court-language, scarce any thing was wrote

* The account given by *Zozimus*, is supported by the testimony of an author of more antiquity, *Clement Alexandrinus*; who, in his *Stromata*, relates that the angels, tho' chose to inhabit heaven, devoting themselves to the pleasures of love, made a discovery to the women of such things as they should have kept secret; and hence, says he, all our knowledge of futurity, and of the sublimest parts of science. This testimony, according to *Borrichius*, wants nothing but the name of chemistry; for as to the thing, it is plainly implied in the sublimest parts of science. But what *gravels Borrichius*, is the source from whence *Clement* and *Zozimus* should derive these facts; he concludes, however, that they had read them in the fragments of the writings of *Enoch*. *Sincellus* has preserv'd us a passage in those writings, which makes the matter clearly out: The angels, says *Enoch*, taught women and men the use of charms, and remedies for diseases. *Exrel*, the tenth in order of the first angels, instructed them to make swords and bucklers, instruments of war, and works of gold and silver, paints, and precious stones for the women. Now, *Sincellus*, according to *Borrichius*, is an author of credit; several historical facts were handed to him from *Manetho*, and *Julius Africanus*, which have since perish'd; besides that the passage now quoted, is confirm'd by a parallel one in *Tertullian*: The fallen angels, says that fa-

ther, first discovered to us the use of gold and silver, the art of dying, of painting the eye-brows, &c. And it was for this, that God first expell'd them heaven, as *Enoch* relates.

Borrichius looks on these passages as so many authentic testimonies; but adds, That *Enoch* was mistaken: The angels here spoke of, were not real angels; they were only the descendants of *Seth* and *Tubal-cain*, who degenerating from their ancestors, gave themselves up to unchaste pleasures with women descended from *Cain*; and among the transports thereof, divulged all the secrets God had trusted them withal.

Agreeably to this origin of chemistry, we find a view kept to love in the progress thereof. Hence, those perpetual allusions; the king's nuptial bed, *Vulcan's* net, the mixture of seeds, the flowing of the menses; in a word, nothing in the affair of generation, but has its symbol in chemistry.

One would suspect that the history of this art were partly borrow'd from the Jewish idolatry; their writings are full of the commerce between angels and women: but the effects thereof are represented as very fatal on both sides. The unhappy passion occasion'd angels to be expell'd from heaven; And the same, according to these writers, was the cause why Man was expell'd paradise.

in *Latin*. They were most of them divines who treated of this art, which was conceiv'd to have a more immediate relation to religion. And hence it is scarce ever mentioned, but in terms that imply such relation: Of the *sacred art*: Of the *Egyptian Art*, *the iisus texvne*, &c.

But in the seventh century, when *Europe* was over-run with the *Barbarians* from the north, *Latin* and *Greek* shared the common fate of learning and arts; and not only the art, but the very name of *Chemia* was totally lost and forgotten. Thus they remain'd till the thirteenth century; when *Bacon* and *Ripley* retrieved, and brought them both on the stage again; not as old things, but taking them for a new doctrine and a new name.

Antiquity of Chemistry.

E'ER we proceed to enquire into the antiquity and original of the practice of chemistry, it may be proper, by the way, to note, in what view we take the art; inasmuch as the different relations, or branches thereof, will furnish different *era's*.

Chemistry, as now conceiv'd, is a system or assemblage of very different parts, which antiently subsisted separate, or at least had a subsistence prior to each other; as the preparing of metals for human uses; the transmutation of baser metals into gold; the procuring of medicines, &c. If, now, we go to trace the antiquity of chemistry, consider'd as it converts other metals into gold; or, as it prepares an universal remedy for all diseases; the research will not carry us far back: but as it relates to the discovery of metals in the mine, and the digging, separating, and purifying of the same, it challenges the highest antiquity.

In this last sense, therefore, it is that we purpose to search into the origin and antiquity of chemistry.

The art of metals is, no doubt, of a very early standing. To find, procure, fuse, refine, render malleable, and apply metals to use, is all of *Antediluvian* invention; and was attributed by the antients to their Gods. *Moses* the oldest author now extant, in his genealogy of the Patriarchs, *Gen 4*. relates that *Tubal-cain* the eighth from *Adam*, was the *instructor of every artificer in brass and iron*, to prepare the instruments and utensils of life. Now 'tis apparent nothing of this could be effected without a thorough acquaintance with the metallurgic art.

For there is no metal requires greater art or industry, for instance, than *copper*, of which *brass* is made; its ore or glebe will sustain the utmost efforts of the fire, and the hammer, without yielding. According to the observations of *Laz. Ercherus*, *Agricola*, and *Helmont*, it must be put seven times successively in fusion, and each time well purged of its *scoria*, e'er it becomes ductile; and fit for use. All which requires no common stock of skill, as well as patience. *Tubal-cain*, therefore, being a master of the management of copper; there was nothing deep or difficult in all the *metallurgia*, but he must have understood.

Again, after copper, the most untractable of all metals, is *iron*. Its ore is a friable matter, pretty easily crumbled into powder; but 'tis with great pains

pains, and the most vehement action of the fire and forge, that it is render'd malleable : yet this was practis'd long before the deluge.

This account of *Moses*, is surprizingly seconded, and confirm'd by prophane history and fables : *Diodorus Siculus*, who lived in the time of *Cæsar*, when *Egypt* was become a *Roman* province, had a fair opportunity of searching into the antiquities of the *Egyptians* : That author relates, as the result of his enquiry, a very antient tradition of one *Heus* ♂, whom that people hold the first inventor of all the arts and operations about metals, and every thing else that undergoes the fire ; together with their uses ; which art he deliver'd down to posterity, so far as it might be of service to mankind. This *Heus* ♂ of the *Egyptians* and *Greeks* is the same with the *Mulciber* or *Vulcan* of the *Romans*, to whom the same art and invention is ascribed ; and the *Vulcan* of the *Latins*, we shall make appear was the *Tubal-cain* of the *Hebrews*.

Or by Vulcan.

Tubalcain and
Vulcan one and
the same person.

Several of the *Roman* antiquaries have labour'd to find the original of the very antient Name, *Vulcan* ; but without Success ; there being nothing in their Language that could lead to it. But *Vossius*, *Jo. Scaliger*, and *Bochart* have determined the point ; and *Vulcan*, by the unanimous consent of the learned, is now acknowledged *תבלין* *Tuvalcain* or *Tubalcain*. The relation between the words is pretty obvious at first sight ; but a little grammatical inquiry makes it much more so : The learned in that language know very well that the first letter of the word, viz. *t* is servile, and does not belong to the root ; this, therefore being set aside, the word stands *Vualcain*, out of which *Vulcan* is easily form'd : But this being a point of some consequence, as well as curiosity, it may deserve to be more particularly insisted on.

The *Asiatic* nations then, we observe, divide their letters into *radical* and *servile*. The first are such as constitute a simple primitive word, or root, whereof others are form'd ; as in the *Latin*, *Callus* is a root, whence, by addition of the servile Letters *o* and *s* is form'd *Callosus* ; and in the *Greek* and *Latin* the Terminations *ia* ♂ and *us* are frequently added as serviles. Now, among the *Asiatics*, the letters *ת*, *ב*, *ל*, are of the species of servile ; which therefore being discarded, together with the points or vowels, which are merely arbitrary ; we shall have *תבלין* which, by changing *B* into *V*, as is common, will be *Vulcan*, and adding the *Latin* termination *us*, *Vulcanus*.

Invention of
fire.

Now it appears from *Homer*, *Hesiod*, *Orpheus*, and all the most antient Writers, that *Vulcan* had the art of working brass and iron ; and that living under mount *Ætna*, he was employ'd in forging arms for the Gods and Heroes. As *Diodorus Siculus* relates the story, he was son of *Jupiter* and *Juno*, and the first king of *Egypt* ; and that he was afterwards preferred to be a God ; for having invented fire, and taught men the use of it. The discovery was occasion'd thus, * happening to see a tree on fire,

* The usual tradition is, that a philosopher meeting with some fire in a grove, preserved there by the Gods ; and feeling it comfortable against the cold, sought how he might have the like, by throwing on Branches of Trees, &c. which gave him the first hint of a combustible matter.

kindled

kindled by lightening, he approached nearer thereto; and perceiving a sense of heat, and withal, that the tree was sensibly consumed, he cast other wood on the blaze, and thus learnt that wood would maintain fire.

It must be added, that the *Egyptians*, as the same *Diodorus* observes, adored their God *Vulcan*, as the inventor of the whole art and application of metals; so that the accounts of *Moses*, and *Diodorus* perfectly coincide, and plainly prove the Chemistry of metals almost coeval with mankind.

Where Chemistry was first invented.

WE proceed in our enquiry to the place where chemistry had its birth; a subject famed for a mighty controversy between the learned *Dane, Ol. Borrichius*, and that monster of erudition *Her. Courtingius*, which divided the chemists of *Europe* into two factions. *Borrichius* strenuously attack'd the antiquity of the art, which *Courtingius* as learnedly defended; between the two, however, abundance of points were admirably discuss'd, which had otherwise never been regarded; so that the public was a gainer by the quarrel. Nor must *Vissius* and *Bochart* be forgotten, from whom we have received divers curious things on the subject, which shew a wonderful harmony between the *Mosaic* and *Egyptian* Annals.

The *Babylonians* and *Egyptians* were in dispute, for many ages, about the origin of the two nations; each advancing many weighty arguments, in proof of their own superior antiquity. 'Tis hard to determine any thing upon the matter, especially at this distance; but thus much must be allowed, that the God of the *Babylonians* was *Horus*, first king of *Assyria*, and inventor of the art of medicine.

Now *Horus* signifies fire, and the *sun*; under the first of which denominations the same deity was worship'd by the *Babylonians*, and under the second by the *Perfians*. Whence we have a strong presumption, that this *Horus* was the same with *Vulkan*, or *Tubal-cain*; in regard each is held the inventor of fire: Beside that *Tubal-cain* lived in *Mesopotamia*. But this we only advance by way of conjecture: indeed, since that noble treasury of books, and manuscripts, founded by *Callisthenes* in *Babylonia*, in the time of *Alexander* the Great, were all miserably destroy'd; we may despair of ever having any further light into the *Babylonish* affairs, from any authentic monuments of history.

By what can be gather'd from history, it appears pretty clearly that the art of chemistry was first found and cultivated in *Egypt*. Chemistry first practised in Egypt. In *Exodus* cap. xxxii. we read that *Moses*, upon his coming down from mount *Sinai*, found a golden calf, which the *Hebrews* had been worshipping; and that he reduced it into a powder, mix'd it with water, and gave it the people to drink. Chemistry then must have been understood by *Moses*, and in perfection too; for 'tis certain, there are but very few among the chymists at this day, deep enough in the *Metallurgia* to do the like.

Now *Moses*, we are told, *Acts* 7. was educated in all the learning of the *Egyptians*; which, if it be no direct and formal proof of chemistry's being practised

practised at that time in *Egypt*; yet, is it of more weight; and concludes more than any other consideration all history affords.

Diodorus Siculus, we have already observ'd, represents the *Egyptians* *Lib. I. c. 2.* as adoring *Vulcan* in quality of inventor of fire, and the art of metals. And the *Greeks*, who knew nothing of the name *Vulcan*, yet speak of *Ἡρακλῆς* in the same quality; and call *Egypt* itself *ἡ γῆ ἡρακλῆα* derived *απο το Ἡρακλῆα* *I burn*; which agrees with what has been afore said. Again *Plutarch de Isid. & Osir. Edit. Par. Xylandri*, relates, that *Egypt* was call'd *chemia*, *αἰγυπτὸν χημίαν καλεῖσιν*. But *Egypt* was also call'd the *black country*, the *hidden country*, &c. and the word chemistry itself has been shewn to have the same signification; so that every thing conspires to one's wish.

Chemistry, therefore, is very properly denominated the *Egyptian Art*, as having been there first practised. Hence *Bochart* notes, that *Egypt* is to this day call'd by divers of the most antient *Asiatic Nations*, *Chemi*, or *Chama*; as in the psalms it is more than once call'd the land of *Ham*.

Stephan. Byzantin. relates that the *Greeks* call'd *Egypt* *ἡ χημική*. *Hermes-chemia*; but we have already hinted that they held *Hermes* the inventor of chemistry: which is a new confirmation.

And with so much zeal and religion did the *Egyptians* cultivate their *Chemia*; that *Herodotus* assures us, they had a temple in the city *Memphis* consecrated to *Vulcan*, the inventor of fire.

Lastly, *Diogen. Laert. de Vitis Philosoph. Lib. 7.* informs us, that in *Zeno's* explication of the word *Vulcan*, it signified *artificial fire*. Now summing up the whole, *Egypt*, land of *Cham* or *Chemi*, *ἡ χημική*, and *ἡ γῆ ἡρακλῆα*, and referring all to *Tubal-cain*, son of *Cham*; it will appear incontestable, that *Egypt* was the country where chemistry was first practised, and *Tubal-cain*, or *Vulcan* the inventor*.

* The country thus settled, the chemists go higher, to fix the precise place thereof where their art was first practiced. The generality put *Thebes*, call'd in the *Egyptian* style *No-Ammen*, where astronomy was first cultivated, in possession of the first chemists: But *Borrichius* rather chuses *Memphis* for the first theatre of the art; his chief reason is, that here was a temple erected to *Vulcan*, as the inventor of the art of working iron.

A reader that can take delight in antient, obscure fables, and modern, learned glosses thereon, may here have his swing; the stories of *Hermes* and *Mercury* will set him up at once; the one king of *Egypt*, the other of *Italy*, but both the inventors of all arts, and chemistry in particular. For *Hermes*, as he was an *Egyptian*, and his story so obscure; there is no harm in admitting him: He might be *Vulcan*, for what

we know, under another Denomination. But that same *Mercury*, who was also call'd *Faunus*, and is only said to have carried his invention from *Italy* to *Egypt*, is in some measure excluded, by what has been shewn of the art's being of *Egyptian* original.

Homer indeed represents *Mercury* as the first, who found the art of managing fire; he also mentions *Apollo's* opening *Hermes's* cave, which was cover'd up with gold; *Venus's* infidelity to her husband *Vulcan*, and her intrigue with *Mars*, in which the chemists plainly find the amalgama of iron and copper, or a perfect image of the grand operation. But instead of troubling the reader with any thing more in this kind, we refer him to *Borrichius de Ortu & Progressu Chemia. Conringius de Hermetica Medicina. Tollius de vitulo Aureo. Hornius's Arca Noë. Kircher's Oedipus Aegyptiacus. Vossius de antiquis Medicis*; and *Bochart*.

Eer

History of CHEMISTRY.

9

E'er we resume the thread of our history, it may be worth while to note the different names, which different nations and authors have given the art; and the rather, as they are all founded on some relation or circumstance thereof.

Its original or *Egyptian* name, then, we have observ'd was *Chemia*; the rise and signification whereof has been already adjusted.

Another very ancient *Greek* denomination is *poietice*, ποιητικη, i. e. *poesy* or *Poety*, ποιητικη, poetry; which we learn from *Zozimus*, who adds (without offence we hope to the poets) that the artists themselves were call'd ποιηται, poets, q. d. makers. It was also call'd *Chrysopoiesis*, χρυσοποιησις, and the artists χρυσοποιηται, q. d. gold-makers. See *Rainerius* on this head, lib. 2. c. 5.

Chrysopoiesis.

The *Arabs* gave it the name *Alchemia* or *Alchemy*, by prefixing, after the manner of their language, the particle *al*, to the *Egyptian* name, to heighten the credit of the art. The æra of this term is fix'd at about four hundred years after Christ: The first author, who mentions it, is *Julius Firmicus Maternus*, who lived under *Constantine* the Great, and who in his *Mathesis*, c. 15. speaking of the influences of the heavenly bodies, affirms, that if the Moon be in the house of *Saturn*, when a child is born, he shall be skill'd in *Alchemy*.

Alchemy.

Paracellus oddly enough styles it the *hyssopic art*, from that passage in the psalms, *purge me with hyssop, and I shall be clean*, by reason chemistry purifies metals. It seems it was a *Jewish* custom to purify with hyssop; and according to *Paracellus*, six of the metals are leprous, or impure, and to be purged of their leprosy by chemistry; therefore, like a strange corner of words, as he was, he must call it the hyssopic art.

Hyssopic Art.

The *Hermetic* and *Trismegistic* art are appellations it derived from its supposed inventor *Hermes Trismegistus*, an antient king of *Egypt*, a thousand years prior to *Æsculapius*. *Trismegistus* is only a *Greek* title or quality added to *Hermes*, signifying as much as the *Latin* *ter maximus*, thrice-greatest. *Zozimus* mentions him as having wrote on natural things.

Hermetic and Trismegistic.

It is also call'd *Pyrotechnia*, or the art of fire; whence that mighty chemist, *Pyrotechnia*, *Helmont*, denominates himself philosopher by fire.

Lastly, it is call'd the *Spagyric art*, some say, from *σπαιρ* and *αγασσιν* to separate and unite; inasmuch as it separates heterogeneous, and joins homogeneous things. But it will admit of some doubt, whether the antient *Adepti* were so well versed in the *Greek* Language.

Spagyric art.

Antiquity of Alchemy.

HAVING shewn the antiquity of chemistry, consider'd with regard to the art of metals; it remains to consider the same with regard to the making of gold, and finding the philosopher's stone.

Now, chemistry taken in this light is usually call'd *Alchemy*, an *Arabic* word form'd by prefixing the augmentative particle *al*, to denote it the most eminent, and sublime part of the art: As, of *gebra* is form'd *algebra*, of *kermes alkermes*, &c. But it must here be remembred that the word

C

alchemy

Two different ob-
jects of Alche-
my.

alchemy has a two-fold acceptation, respecting the two different things which it pursues: viz. 1. The secret of making gold from any other metal. 2. An universal medicine for the cure of all diseases; which is a distinction of the utmost moment, in an inquiry into the origin of alchemy.

Antiquity of the
art of making
gold.

Our first business then shall be to settle the æra of alchemy, as it proposes the making of gold. This, we venture to say, is not near so antient as the art of metals; nor do we find any trace thereof before the third century.

The antient Po-
ets; unacquainted
therewith.
And philosophers.

The chemists indeed go higher, and will abate nothing of the age of *Adam*: That patriarch, they say, was no stranger to the art of making gold; which he taught his descendants: tho' it had the fortune to be lost at the flood; and was only restored by *Moses*, and his sister, by whom it has been handed down without interruption thro' the succeeding ages. But a matter of history is only to be demonstrated from monuments of history; and the antient historians, poets, &c. are all perfectly silent, as to any such thing. Neither *Orpheus*, *Homer*, nor *Hesiod*, nor any of the *Latin* scholiasts or antiquaries, or any of their commentators, mention any thing of the matter. And what would not the poets have given for such a boundless field of fiction and fancy? *Aristotle*, assisted by *Alexander* the Great, master of all the antiquities of the *Persians*, *Chaldeans*, *Babylonians*, *Egyptians*, *Hebrews*, and *Greeks*; this *Aristotle*: who described the properties of bodies, and all their physical mutations, has not one word of the philosopher's-stone: And can it then be thought possible, the *Egyptians*, the people of *Asia* and *India*, shou'd have had any such secret? *Theophrastus* was *Aristotle*'s disciple; he writ of vegetables, stones, metals, and fossils, of gold, silver, mercury, and all the minerals; and beside his own stock of knowledge, was master of all the works of *Aristotle*: yet he takes no notice of the transmutation. *Pliny*, that indefatigable naturalist, who compiled his work from so many thousand volumes; who search'd with unwearyed pains into every thing strange, and out of the way; and who has comprehended almost all the monuments of art and nature within his pandects, never mentions any thing like a philosopher's-stone, which should transmute metals, in all their substance, into gold. In all the historians we find nothing to countenance this imaginary antiquity; nothing that shews it to have been talk'd of even in *Galen*'s time*. For we bar the conjectures which the chemists use to advance on this occasion; as in truth they are no better than chimæras: What, for instance, can be more so than to find the

* *Suidas* endeavours to ward off this objection. *Diocletian*, he observes, procured all the books of the antient *Egyptians* to be burned; and it was in these books the great mysteries of chemistry were contain'd. *Covringius* calls this history in question, and asks how *Suidas*, who lived but 500 years before us, should know what happen'd 800 years before him? To which *Borrichius* answers, that he had learnt it of *Eudemus*, *Helladius*, *Zozimus*, *Pamphilus*, &c. as *Suidas* himself relates.

doctrine of making gold couch'd in the story of the *Argonauts* *, the books of *Moses*, and the revelations? The same spirit might find the longitude, and the perpetual motion in the same.

The first author who has a tittle of the matter, is *Aeneas Garaus*, a The first author who mentions it. a Greek, who lived towards the close of the fifth century, and wrote a comment on *Theophrastus*. In the latter part of the work, he has a passage to the following effect: *Such as are skill'd in the ways of nature, can take silver, and tin; and, changing their former nature, make them into gold.* This seems to imply as if some such art were then in being; but as he relates nothing expressly how long it had been known, his testimony will not carry us back beyond his own time: for we should assert no further than we find. The same author tells us he was wont to style himself *χρυσοςχοος*, gold-finder, or *χημικος*, chemist; and is the first who uses the word *χουροποιος*, as applied to this art.

The next is *Anastafius* the *Sinaite*, who is about fifty years posterior to *Garaus*. From a passage in this author we learn, that there were alchemists in his time. In a defence of himself against some Impeachments of his adversaries, he has these words; *You ought not to call us alchemists*: which is an argument there were people at that time who profess'd the art.

After these two authors, follow a croud of no less than fifty more, all on the subject of alchemy, all *Greeks*, and most, or all of them, monks; their names need not be rehears'd: the principal of 'em are *Syncellus*, *Rinnesius*, *Stephanus*, *Olimpiodorus*, *Dioscurus*, *Ostanes*, &c.

The art seem'd now confined to the *Greeks*, and among them few wrote but the religious; who, from their great laziness, and solitary way of life, were led into vain enthusiastical speculations, to the great disservice, and adulteration of the art. The greater part of them are yet in manuscript, and like to continue so, till chemistry is more studied, or the chemists know more *Greek*. They are all wrote in the natural style of the school-men, full of jargon, grimace, and obscurity.

Against what we have alledged concerning the novelty of alchemy, *Borrichius* quotes a passage from *Pliny*, lib. 33. c. 4. on which he lays a deal of stress and confidence. That naturalist observes, *There is one way of making gold, from orpiment*——*Caius Caligula* was tempted by his avarice to make the experiment. Accordingly, he caus'd a considerable quantity of the mineral to be distill'd. The result was, that he did indeed obtain gold, and of the finest kind; but in so small quantity, and with so much labour and apparatus, that the profit not countervailing the expence, he desisted. His ill success has deter'd any body from ever making the like experiment †.

But.

* *Suidas* will have the secret of the philosopher's-stone contained in the fable of the golden fleece; which, according to him, is a mere poetical fiction, describing the process of making gold. But unless

he could bring better vouchers for his opinion, it will pass for no better than a fiction itself.

† *Borrichius* imagines, that what put *Caligula* upon the thought, was that oracle of

History of CHEMISTRY.

But this account makes very little for the pretensions of *Borrichius*. Here was no transmutation of lead, or tin, into gold: no hint of any philosopher's-stone; only, a small quantity of gold was extracted. And no wonder; when we know that gold, more or less, is procurable, by separation, from every metal: tho' it commonly proves *Caligula's* case; the gold thus gain'd not being worth the fire.

Another passage which the chemists produce from the same author, makes still less for their purpose. *In the reign of Tiberius, 'tis reported, an artist had found the secret of tempering glass, so as to render it malleable; but the inventor was made away withal, and his work-house put down, for fear this new manufacture should lower the value of gold, silver, and other metals. But this report was more current than certain.* Allowing the fact for true, we don't see what stead it will stand them in*.

Antiquity of the
universal medi-
cine.

Let us now see what pretensions alchemy has to antiquity, consider'd as it aims at an universal remedy, effectual in all diseases; or even at any remedy at all. This appears, of all others, the latest branch of the art. Many are of opinion, that all preparation of metals, and other matters for medicinal uses, was utterly unknown to the antients; and first introduced by *Paracelsus*.

Borrichius, however, pleads strenuously for the antiquity of this branch; and employs a deal of learning and subtilty to prove it ante-diluvian, and *Hermes Trismegistus* the author. Now, the fate of every art is only to be exhibited from the monuments of history: and some author should here be produced to warrant this antiquity; by relating, that the art was invented, or cultivated in such or such an age.

But *Borrichius* will have it antient without any such voucher: the chief ground he goes on, is a single passage in *St. Jerom*, who speaking of *Hermes*, says he was a great physician. But is this a proof of his having the art of making gold out of baser metals, and of making a medicine by means thereof that should cure all diseases?

No mention of it
among the an-
cient historians.

History, in effect, affords no ground for the opinion: *Moses*, the oldest writer extant, and those who came next after him, are silent on the point; and yet *Moses* was an adept in all the discipline of the *Egyptians*, and relates the origin of all the Arts from *Adam* to *Noah*; and had a fair opportunity for this, in treating of the *Lepra* in *Leviticus*, had he known

of the *Sybil's*, *Tetrasyllabus sum, prima pars mei virum, secunda victoriam significat*; which the chemists generally suppose to contain a mystery, and to be spoke of arsenic, whereof orpiment is a species. Tho' *Kircher* will have the oracle applied to our Saviour.

* *Kircher*, indeed, asserts, that the theory of the philosopher's-stone is contain'd in the table of *Hermes*; and that the antient *E-*

gyptians were not ignorant of the art, but declined to prosecute it. They did not need to transmute gold; they had ways of separating it from all kind of bodies, from the very mud of the *Nile*, and stones of all kinds. But he adds, these secrets were never wrote down, or made publick, but confined to the royal family, and handed down traditionally from father to son. So that all strict evidence is at once excluded.

it. From *Moses* to the *Babylonish* captivity, we have no historian: the first that appears, is the *Phenician*, *Sanchoniatho*, who was cotemporary with *Zerobabel*: to him we are indebted for what we know of the *Phenician* and *Grecian* antiquities; but he has not one word of the philosopher's-stone, or the grand medicine. *Herodorus* and *Thucydides* don't afford us any more light; and yet the former is very particular in enumerating the arts of the *Egyptians*. He adds, somewhere, "that *Darius Hy-*
taspes having broke his leg, sent for physicians from *Egypt*; but that the
 "cure did not succeed to his expectation, till a physician of the family of
 "the *Asclepiades* was call'd in." But no mention here of any universal medicine. Consult *Dioscorides*, who travel'd thro' *Chaldea*, *Persia*, *Babylon*, *Egypt*, *Africa*, *Europe*, and other regions, and collected every thing relating to the art of physic: does he mention any thing of an universal medicine? Not a syllable. *Aetius* collected his *Tetrabiblos* from all the writers then known, and from a thousand now lost: he is very express in rehearsing all the *arcana* for the several diseases; and his work is a kind of index, or inventory of all antiquity. Yet no hint of any such medicine in him. Ask *Hippocrates*, who, according to *Zoramus's* account, pass'd thro' all *Egypt*, *Africa*, and the coasts of the mediterranean sea, to make discoveries and improvements in his art; and ask *Galen*, too, who was no less laborious an enquirer, why they all took such pains, by slow, imperceptible means to improve their art, when they had it in their power to cure all the Infirmities of human nature, by a single preparation, known to so many persons? Is it possible that *Galen*, who published an account of all the sects and writers among the physicians, should be so inadvertent as to forget so singular a body of enthusiastical quacks; had they been then in being? A pretender to an universal remedy could never have escaped the gall of his pen.

'Tis highly probable it was the *Arab*, *Geber*, that first occasion'd people to turn their thoughts this way; and set them a madding after such a medicine. His words are, *There is a medicine which cures all lepers, or leprous persons*. But by attending to the *Arabic* style, and diction of this author, which, according to the genius of that language abounds in allegory, it will appear, that by *man*, he means gold; and by diseases, or *lepers*, the other metals, which all recede, more or less, from the purity and perfection of gold.

Authors and Improvers of Chemistry.

THE *Origines* of chemistry, or the first rudiments of the art, thus laid, we proceed to relate the progress thereof; and who the principal authors were that contributed to its advancement, as well as those who corrupted it; at the same time noting their several writings, the best editions thereof, and the order wherein they are to be read.

And here we judge it proper to distinguish the chemists into three classes; either as they treat of metals, of alchemy, or medicine.

ZOZIMUS

400.
Zosimus.

ZOSIMUS the Panopolitan leads the band of chemical authors*. The circumstances of principal note in his history we have already related. His writings are, 1^o, *περὶ τῆς ἱερᾶς τέχνης τοῦ χρυσοῦ καὶ τοῦ ἀργυροῦ ποιήσεως*, Of the divine art of making gold and silver. 2^o, *περὶ τῆς γῆς*, Of the virtue and composition of earth. 3^o, *περὶ τῶν ὀργάνων καὶ καύων*, Of chemical instruments and furnaces. 4^o, *περὶ τῆς ὑλῆς ἀκαυστῆς*, Of the incumbustible matter. As also, 5^o, Of waters. 6^o, Of divine arts. And, lastly, of mysteries. They had lain a long time conceal'd in the French king's library; and had the fortune to be first discovered by *Jos. Scaliger*; as he himself relates in his notes on *Eusebius*; since whom, they have also been perused by *Borrichius*, *Comringius*, and *Rheinesius*.

700.
And other
Greeks.

After Zosimus came a troop of Greek monks, *Garaus*, *Anastafius*, and fifty more, of whom we know little more than the names. There is nothing extant in print of any of them; but their writings are still found in manuscript in the great libraries of *Rome*, *Venice*, and *Paris*. 'Tis, perhaps, no great detriment to the art, in the main, that they are not more known, and read; there being a vein of rhodomontade and obscurity running thro' 'em, which might give ill impressions on the art. After these Greeks, came the Arabs.

800.
Geber.

GEBER, surnamed the Arab, presents himself as the first great reformer and improver of chemistry. His history is very obscure: The name *Geber* in the Arabic language signifies a great man, and a king; whence he is commonly supposed to have been a prince; and, as he wrote in Arabic, a prince of Arabia. But *Leo Africanus*, a Greek, who wrote of the antiquity of the Arabs, gives another account. *Geber*, according to this writer, lib. 3. c. 106. was originally a Greek, and a christian; but afterwards embraced mahometanism; went over into Asia, and there learn'd the Arabic tongue. He adds, that his book was wrote in Greek, and translated thence into Arabic; and that he was not known by the name *Geber*, till after this version.

Galius, professor of the oriental languages in the university of *Leiden*, made the first present of *Geber's* piece, in manuscript, to the publick library; and translated it into Latin, and publish'd it in the same city, in Folio; and afterwards in Quarto, under the title of *Lapis Philosophorum*. It contains abundance of curious and useful things about the nature of metals, their purification, fusion, malleability, &c. with excellent accounts of salts, and *aqua fortes*. Abundance of his experiments are verified by present practice; and several of them have pass'd for modern Discoveries. Except for what relates to the philosopher's-stone, the exactness of his operations is really surprizing. He seems to have liv'd in the 8th century.

* We have chemical writings, indeed, which pretend to much greater antiquity; but they are all apparently spurious and modern: such is the table of emeralds attributed to *Hermes*, notwithstanding all

Borrichius can do to prove it antique: 'tis not once mention'd in any author of any standing. Such also are the books of *Solomon*, *Mary the prophetess*, *Osian*, *Democritus*, &c.

He

He is supposed to have given the first handle to any enquiry after an universal medicine; there being some expressions in his book, which might easily enough lead an unwary reader to think he was acquainted therewith. As, *Gold thus prepared cures lepra's, cures all diseases, &c.* But we are here to observe, that in his language, the coarser metals are all leprous men; and gold a healthy one. When, therefore, he says, *I will cure six lepers*, he means no more than that he will turn them into gold, which shall bear the tryal of antimony. But as he was no physician, 'tis more than probable he never thought of any universal remedy himself. After this writer, we don't meet with any other of distinction, till the 12th century.

ALBERTUS MAGNUS began to flourish in this age, born in the year 1200; was first a monk, then bishop of *Ratisbon*. He distinguish'd himself chiefly as a philosopher: but this did not hinder his having a peculiar devotion to chemistry. By a general correspondence with all the miners throughout *Germany*, he got a very uncommon insight into the art of metals.

1200.
Albertus Magnus.

He wrote a great number of books, on various subjects; as, *de secretis mulierum*, &c. But his chemical works are few, and those very hard to be met withal.*

ROGER BACON, vulgarly call'd *Friar Bacon*, made his appearance about the same time; the glory, and at the same time the shame of the age. We first hear of him at *Oxford*, in the year 1226, as a fellow of a college; but he afterwards embraced the monastic state, and lived a religious in the abbey of *Westminster*. He was beyond all comparison the top-man of those times; and might, perhaps, stand in competition with the greatest that have appeared since. 'Tis wonderful, considering the ignorant age wherein he liv'd, how he came by such a depth of knowledge, on all subjects. His treatises are compos'd with that elegance, conciseness, and strength, and abound with such just and exquisite observations on nature, that, among the whole tribe of chemists, we don't know one that can pretend to contend with him. The reputation of his uncommon learning still survives in *England*. His cell is shewn at *Oxford* to this day; and there is a tradition, that it will fall, whenever a greater man than *Bacon* shall enter within it.

1226.
Friar Bacon's history.

He wrote many treatises; amongst which, such as are yet extant, have beauties enough to make us sensible of the great loss of the rest. What relate to chemistry, are two small pieces wrote at *Oxford*, which are now in print, and the manuscripts to be seen in the public library of *Leiden*; having been carried thither among *Vossius's* manuscripts from *England*. In

His writings.

* *Albertus Magnus*, now known by upward of twenty volumes in *Folio*, is said to have been first distinguished by his dulness and stupidity; insomuch that he became the common jest of his fellow-students. At length, quite tired out, he resolved to scale the walls of the convent, and run away. In this attempt, the holy virgin appear'd to him on the wall, and there gave him that understanding and ability which have since render'd him so famous. Such is the origin of the 22 folio volumes.

these

His dogma's.

these treatises he shews how imperfect metals may be ripen'd into perfect ones. He entirely adopts *Geber's* notion, that mercury is the common basis of all metals, and sulphur the cement; and shews, that it is by a gradual depuration of the mercurial matter by sublimation, and the accession of a subtle sulphur, by fire, that nature makes her gold; and that if, during the process, any other third matter happen to intervene, beside the mercury and sulphur, some other baser metals will arise: so that if we could but imitate nature's method, for instance, of ripening lead; we might change it into gold.

Several of *Bacon's* operations we have compar'd with the modern experiments of *Monfieur Homberg*, made by direction of that curious prince the duke of *Orleans*; and can attest, that *Bacon* has described some of the very things which *Homberg* publishes as his own discoveries. Thus, for instance, *Bacon* teaches expressly, that if a pure sulphur be united with mercury, it will commence gold: on which very principle *Monf. Homberg* has made divers experiments for the production of gold, described in the *Memoires de l'Academ. Royale des Sciences* *.

His other physical writings shew no less genius, and force of mind. In a treatise, † *Of the secret works of nature*, he shews, that a person who was perfectly acquainted with the manner nature observes in her operations, would not only be able to rival, but to surpass nature herself. He has another piece, ‡ *Of the nullity of magic*, wherein, with great sagacity and penetration, he shews how the notion first got footing, and how weak all pretensions thereto are. Admiration, the parent of magic, is the offspring of ignorance, begot upon a vitiated imagination: When weak minds perceive an effect, whose cause is hid far in the dark, they presently have recourse to a demon to solve the difficulty; it must be the effect of magical art, or the intervention of some supernatural power, that's plain. This popular refuge of ignorance the judicious author deservedly confutes, and shews there is no such thing as magic, unless by that word be meant

* *M. Homberg*, in his *Essai du souffre principe*, from two experiments, the one with mercury, (which expos'd to a digesting heat, ceases to be fluid, gathers into a powder heavier than mercury, and at length acquires such a fixedness, as to remain red-hot twenty-four hours, without loss; tho' upon applying a naked fire, the whole flies off in fumes, only leaving a piece of hard metal, form'd of the mercury, behind;) the other with regulus of antimony, (which, being expos'd to the duke of *Orleans's* great burning-glass, to calcine, gain'd $\frac{1}{10}$ part in weight;) concludes, that light may be introduced into porous bodies, may there fix, and increase both their weight and bulk: and the light thus retain'd in mercury, becomes inseparable therefrom, in the most vehement fire; and even changes the form of the mercury into a malleable ductile metal, heavier than any other metal, except gold. *Mem. de l'Acad. an. 1705.*

In another place the same author argues, that gold consists principally of two kinds of matter, viz. mercury, or quick-silver, and a metallic sulphur, (which, according to him, is no other than Light) either of which, taken a-part, evaporates with the least heat; but, when join'd together into a metal, after the manner just mention'd, they lose their volatility, and become so fix'd, that the most intense fire of our laboratories cannot separate them. *Mem. de l'Acad. an. 1707.*

† *De secretis naturæ operibus.*

‡ *De nullitate magiæ.*

a knowledge of the properties of bodies, and the methods of nature; by a dextrous application, whereof many things may be produced more surprizing than all the magic in the world has ever yet effected.

Such was the scope and tendency of his writings. What reward he met withal, is abominable to say: the man who had thus overthrown the idle pretensions of the believers in magic, was himself branded for a magician, excommunicated, and condemned to the flames: a fate which has been shared with him, in some measure, by the greatest and most deserving persons of many ages, and for the noblest causes: witness *Gallileo*, *Hildebrand*, and *Vigilius*, for asserting the motion of the earth, the antipodes, &c.

This author's works are printed in 8° and 12°, under the title of, *Frater Rogerius Baco de secretis artis & nature*; but are very rarely to be met withal. From a repeated perusal of them, we find, our friar was no stranger to many of the capital discoveries of the present, and past ages.

Gun-powder he certainly knew: thunder and lightning, he tells us, may be produced by art; for that sulphur, nitre, and charcoal, which, when separate, have no sensible effect, when mingled together in a due proportion, and closely confined, yield a horrible crack. A more precise description of gun-powder cannot be given in words: and yet a jesuit, *Barthol. Schwartz*, some ages after, has had the glory of the discovery.

He likewise mentions a sort of inextinguishable fire, prepared by art: which shews, he was not unacquainted with phosphorus.

And that he had a notion of the rarefaction of the air, and the structure of an air-pump, is past contradiction. A chariot, he observes, might be framed on the principles of mechanics; which, being sustain'd on very large globes specifically lighter than air, would carry a man aloft through the atmosphere. *Sturmius* has since taken notice of the project, and shewn how to put it in practice: four hollow spheres are to be provided, all exceedingly thin, yet firm enough to sustain the pressure of the air; and on these a chair, or chariot, to be placed: then, exhausting the air out of the globes, they will be taken up aloft, with their burden; and the person mounted thereon letting the air gradually enter by means of a cock, may subside at pleasure. Indeed, 'twould be very difficult procuring such spheres; but it were impossible, without supposing the gravity, pressure, and elasticity of the air: our author, therefore, in averring the thing feasible, gives an indication of his knowing some things which pass among us for late discoveries.

There are many other curious speculations in the noble author, which will raise the admiration of the reader; but none of them will affect him, with so much wonder, as to see a person of the most sublime merit fall a sacrifice to the wanton zeal of credulous bigots.

Lully.

RAYMUND LULLY, or *Ramon Lull*, comes the next in order. He was born in the island of *Majorca* in the year 1225, of a family of the first distinction; tho' he did not assume his chemical character till toward the latter part of his life. The authors of that time speak of him as a person eminently versed in the peripatetic learning; and, indeed, a great many of his writings witness no less. He had the address to introduce a new kind of *transcendental* art, called, from him, the *Lullian* art; by virtue whereof, a man might dispute whole days upon any topic in nature, without understanding any thing of the matter in dispute. The drift of this doctrine was to dispose the several sorts of beings into divers climax's, or scales, to be run down in a descending progression. Thus, whatever were proposed to be talked on; they would say, first, it is a *Being*; and, consequently, *one*; *true*; *good*: then, every *Being* is either *created*, or *uncreated*: and every *created Being* is either *body*, or *spirit*, &c. But, at length, perceiving the vanity of his own art, he quitted this barren superfluity of words, and went over to the other extreme.

Lully's art.

Upon his applying himself to chemistry, he soon began to preach another sort of doctrine; inasmuch, that, speaking of that art, he says it is only to be acquired by dint of experiment, and cannot be conveyed to the understanding by idle words, and sounds. He is the first author I can find who considers alchemy expressly with a view to the universal medicine: but after him it became a popular pursuit, and the libraries are full of writings in that vein.

His writings.

Lully himself, beside what he wrote in the scholastic way, has a good many volumes, wrote after his conversion: 'tis difficult to say how many; for it was a common practice with his disciples, and followers, to utter in their performances under their master's name. I have perused the best part of his works; and find them beyond all expectation, excellent: inasmuch that I have been almost tempted to doubt whether they could be the work of that age. So full are they of the experiments and observations which occur in our later writers, that either the books must be suppositions, or the antient chemists must have been acquainted with a world of things which pass for the discoveries of modern practice. He gives very plain intimations of phosphorus, which he calls the *vestal fire*; the *Offa Helmontii*, &c. And yet it is certain he wrote 200 years before either *Helmont*, or my Lord *Bacon*.

And discoveries.

He travelled into *Mauritania*, where he is supposed to have first met with chemistry; and to have imbibed his principles of the art from the writings of *Geber*: which opinion is countenanced by the conformity observable between the two.

The *Spanish* authors ascribe the occasion of his journey to an amour: he was fallen in love, it seems, with a maid of that country, who obstinately refused his addresses. Upon enquiring into the reason, she shew'd him a cancer'd breast. Lully, like a generous gallant, immediately resolves on a voyage to *Mauritania*, where *Geber* had lived; to seek some relief for his mistress. He ended his days in *Africa*; where, having taken up the quality

lity of missionary, and preaching the gospel among the infidels, he was stoned to death*.

ARNOLDUS DE VILLA NOVA, or *Arnoud de Ville Neuve*, a Frenchman, thus denominated from the place where he was born, viz. *Ville Neuve*; is by some supposed to have been *Lully's* master; but others, with more probability, take him to have been his disciple. *Arnoldus* flourish'd in the 13th century. He was the first physician of that time; and in that quality served the then pope. His writings shew him an excellent chemist, and even deep in alchemy. *Van-Helmont*, a great admirer of *Arnoud*, attributes to him the first introducing of chemistry into medicine.

He wrote a great many pieces, which are collected together in a folio volume, under the title of, *Magistri de Villa-nova*; and easy enough to be had. At the end is a little treatise of alchemy, perfectly in the manner, and on the principles of *Geber* and *Lully*. He is every where a strenuous advocate

* The history of this eminent adept is very much imbroil'd. Authors speak of him very differently; and 'tis not easy, on the whole, to decide whether ever he were a chemist, or wrote at all on the subject, or not. *Vincent. Mutius*, who writes the history of *Majorca*, shews him in a very different light: *Lully's* father, says he, was descended of a noble family; and his mother, of the house of the counts d'Eril. He was born in 1235. His first inclinations led him to study, which he afterwards quitted to follow arms. In this profession he had leisure for love, and entertain'd a passion for a maid, named *Eleanora*. One day, as he was viewing her with languishing eyes, she laid bare her bosom, and shew'd her lover a cancer that had consumed her breasts. *Lully*, struck speechless at the sight, immediately sequester'd himself to solitude and anxiety. In the excess of his despair, a crucifix appear'd to him; which, inspiring new courage, set him above the concerns of the world. The remainder of his life, therefore, he devotes to penance; and, among other pious exercises, applies himself to the conversion of infidels: with a view to which, he learn'd *Arabic* at thirty years of age. At his solicitation, *James* king of *Arragon* founded a seminary in *Majorca*, for the education of missionaries. After which, he travel'd thro' *France*, *Germany*, and *England*; and was at last put to death in *Africa* for preaching christi-

Now in all this relation, what have we that looks any thing like chemistry, or the philosopher's stone? *Mutius* is even express, that that good man, wholly intent upon religion, never applied himself thereto: and yet we have divers accounts in history of his making gold. Among other authorities, *Gregory of Tholouse* furnishes one: "*Lully*," says that author, "offered king *Edward III.* of *England*, a supply of six millions to make war against the infidels." To which may be added another from *Rob. Constantine*: "I have made enquiry, and find, that *Lully* actually perform'd, what his Books pretend he did, in *England*; and that he made real gold in the tower of *London* by the king's order." What discredits the relation and the historical writings whereon 'tis chiefly founded, is, that king *Edward* was only three years old, when *Lully* died: tho' this is not the only inconsistency; for in his books, he is said to have made experiments at *Milan* in the year 1335; when 'tis certain he died in 1315.

Borrichius, however, will have the testimonies above-mentioned to be authentic; and fathers the faults in chronology on the copists. Be this as it will: beside manuscripts, the following printed pieces bear *Lully's* name; viz. *The theory of the philosopher's-stone*: *The practice*: *The transmutation of the soul*: *The codicil*: *The vade-mecum*: *The book of experiments*: *The explanation of his testament*: *The abridgments, or accusations*: and, *The power of riches*.

for an universal medicine; and says a deal to shew that there is such a thing in nature*.

Johannes de Rupe Scissa.

JOHANNES DE RUPE SCISSA comes next in turn. He was a *Franciscan* fryar, and flourish'd about the year 1380. He is a voluminous author; but his writings are of great weight and importance. Beside his theological pieces, he wrote many chemical ones; and had wrote more, as having a strong chemical taste, but that the good man, like his great predecessor *Bacon*, was accused of magic, and thrown into prison; where he pined and died away of grief: and by such means was prevented the discovering a great many secrets of nature, which he was become master of. He is held the patriarch of the chemists. His works are easy to be procured.

Ripley.

GEORGE RIPLEY, an *Englishman* by nation; and by profession a canon, or monk of *Britlington*, succeeds. His writings are all very good in their kind, being wrote exactly in *Bacon's* manner, only more allegorical. As he was no physician, he does not meddle with any thing of the preparations of that kind; but treats much of the cure of metals, which, in his language, is the purification and maturation thereof. He pursued *Geber's* and *Bacon's* principles very religiously; and maintain'd, for instance, with new evidence, that mercury is the universal matter of all metals; that this, set over the fire with the purest sulphur, will become gold; but that if either of them be sick or leprous, that is, infected with any impurity, instead of gold, some other metal will be produced. He adds, that as mercury and sulphur are sufficient for the making of all metals; so, of these, may an universal medicine, or metal, be produced, for curing of all the sick; which some, mistakenly, understood of an universal metal, efficacious in all diseases of the human body.

His dogma's.

Jo. and II. Hollandus.

JOHN and ISAAC HOLLANDUS, two brothers, come next. 'Tis not easy to say what countrymen they were; whether *Englishmen*, or, as their name may seem to import, *Hollanders*: we have in our keeping two manuscript copies of their works; one in the *English*, and the other *Low-Dutch* language: tho' we rather incline to think the *Dutch* the original, and the *English* a translation†.

Their inventions.

They were both of them persons of great parts and ingenuity, and wrote on the dry topics of chemistry, with all the copious eloquence of orators. They seem to have lived in the 13th century; but this is not assured. The whole art of *enamelling* is their invention; as is also that of *colouring glass*, and *precious stones*, by application of thin metal plates thereon.

* *Arnoldus* is mention'd by other authors, as physician to *Frederic* king of *Arragon*, and afterwards *Sicily*; and to have been occasionally sent by that prince to pope *Clement*, who was then sick: but he perish'd by shipwreck on the voyage, in the year 1310. *Nouv. Cours de Chymie*. Jo. And, *l'Esu* relates his performing several

transmutations at the court of *Rome*. The titles of his several pieces are, *The rosary of Arnoldus*: *Flower of flowers*; *Chemical letter to the king of Naples*: *The new light*: *The questions of Pope Boniface VIII. with answers thereto*: And, *The mirror of alchemy*.

† The *Dutch* manuscript is here and there interpolated with *English*.

Their

Their writings are in the form of processes; and they describe all the operations, to the most minute circumstances. The treatise of *enamelling* is esteem'd the greatest, and most finish'd part of their works; whatever relates to the fusion, separation, and preparation of metals is here deliver'd. They write excellently of *distillation*, *fermentation*, *putrefaction*, and their effects; and seem to have understood, at least as much of these matters, as any of the moderns have done. They publish'd a small treatise of the *philosopher's-stone*; which, they hold, may be prepared from any body in nature. They describe ways of producing it from lead, blood, sulphur and mercury, and other matters. They furnish a great many experiments on human blood; which *Van Helmont* and *Mr. Boyle* have since taken for new discoveries. I have a very large work in *folio* under their name, of the construction of *chemical furnaces and instruments*.

Their writings were first publish'd in separate volumes, which are as easily purchased as they are worthy of perusal, for the sake of some valuable secrets contain'd therein, which may pave the way for the greatest discoveries.

All the authors hitherto rehears'd have been confined to the *metallurgia*; or at least to some one or two peculiar bodies: Metals, for instance, glass, and precious stones were thus long the whole field and subject of chemistry, about which all the chemists from *Zozimus* to *Hollandus* were employ'd. We shall only here take occasion to add, in the general, that it is no valid objection against the art or veracity of any of 'em, that in some places we don't conceive or understand 'em; since, wherever we do, there they always speak true: This is certainly a strong presumption in favour of the truth of things, which surpasses our comprehension.

We now proceed to the second order, or class of chemists: viz. Those who have cultivated the art with a view to Medicine; whether in order to a discovery of an universal remedy for all Diseases, or of particular ones in the ordinary way of physic.

BASIL VALENTINE is the first in this list: But who he was, or whence he came, is but little known; for the name is apparently fictitious: He is commonly said to have been a *Benedictine* monk, of a Monastery at *Erphurt*, which is the quality he assumes in his writings; but there is no trace, or memory of such a person at *Erphurt*; nor was there ever any *Benedictine* monastery there; whence, it looks more probable he was some great man, who, according to the custom of that age, chose to veil himself under this appellation. *Helmont*, who took a deal of pains in the enquiry, shews he was prior to *Paracelsus* by a hundred years; and that he lived in 1415. Some fix his birth to the year 1394.

His writings are much commended, and much sought; tho' there are some spurious pieces tack'd to 'em. He wrote all in *High Dutch*, and 'tis but few of his pieces that have been translated into *Latin*. In matters of experiments he may be depended on for his exactness, and veracity: His style is clean, open, and pure; except when he treats of his arcanums, and particularly of the philosopher's-stone; where he is as cloudy as the rest.

By

The first that ap-
plied chemistry
to medicine.

By what appears, it was he who first applied chemistry to medicine; for, after every preparation, he never fails to give some medicinal use thereof. He owns that he practised physic himself; and had prescribed a *Lithontrip* tic to the great chancellor of the empire; whereby a stone in his bladder was actually dissolved.

One blemish in his character, which indeed runs thro' the whole tribe of his followers, is, that he is too liberal in the uses, and virtues of his preparations. Thus in his *triumphal chariot of Antimony*; a mineral, which we are to observe, was the basis of almost all his medicines; we meet with nothing but grand, catholic, universal remedies.

His dogma's and
discoveries.

One thing certainly redounds much to his glory: viz. That his stock of chemical knowledge has served abundance of his Successors to spend on. It was he, who first broach'd the doctrine of the three chemical principles, *Salt, Sulphur, and Mercury*, which *Paracelsus* afterwards appropriated; and it might be shewn, that both *Paracelsus*, and *Helmont*, and many others of modern fame, owe a great part of what is most valuable in 'em, to this author: So that it is not without reason, that he is judg'd the father of the modern chemists, and the founder of the chemical pharmacy.

In his *currus triumphalis Antimonii* we meet with all the experiments and preparations, which the younger *Lemery* has in his late *French* treatise de l'*Antimoine*; and yet *Lemery* puts 'em all off, as if they were new, and his own.

Van Helmont had writ much about the *alcahest*, or universal menstruum, and *Zwelfer* pretends to have known his secret: He describes it as a preparation of vinegar and copper-rust distill'd, till the copper quite disappears. But *Otto Tachenius* shews, that *Zwelfer* borrow'd the whole process from a book of *Valentine's*, entitled *Standgeist*; where, indeed it is described in terms plain enough.

So the *sal volatile oleosum*, which *Sylvius de la Boe* has long had the credit of; and many other secrets which make a figure in the modern authors, are really originally derived from *Basil Valentine*.

Paracelsus.

PARACELSUS comes next on the stage; a great, anomalous, unaccountable fellow; whose history will have all the air of paradox. He reform'd and alter'd the face of medicine, and turn'd it altogether into the vein of chemistry; being the first of all mankind, who, of a profess'd chemist, was made a public Professor of medicine in an university. Never did any person bear such different, inconsistent characters as the author we are now about to treat of: amid so much diversity, it will require no small degree of attention and address, to keep the truth in view, and pursue it without deviating into any of the tracks of fable and fiction. To hear the generality of chemists talk, he was nothing less than a God; nay, 'tis a tradition, which I find several people believe, that he is not dead, but still lives in his tomb; whither he retired, weary of the vices and follies of mankind. And yet others represent him as one of the most vile, flagitious, and worthless of the race of men.

To

To ascertain somewhat of the character of this memorable person, we have consulted all the writers on both sides the question; and will give you his story, not as 'tis drawn by his profess'd Devotees, the *Paracelsists*; nor yet from those, who determinately vilify him at all adventures; as *Erastus*, *Theophilus*, &c. But, principally, as deliver'd by *J. Oporinus*, a Greek professor in the same university with *Paracelsus*; by *J. Crato a Krasibeu*, an illustrious physician of that time, who conversed with *Paracelsus*, and whose writings have all the marks of candour and exactness; and by *Van Helmont*, who travel'd into *Germany*, on purpose to enquire into the matter, and satisfy himself of the truth of the stories related of our philosopher: Tho' as to this last author, we shall be a little on our guard, as he appears strongly inclined in favour of his master, and has publickly declared *Paracelsus* the prince of physicians, and philosophers by fire. We now come to the point.

PHILIP AUREOLUS THEOPHRASTUS PARACELSUS BOMBAST DE HOENHERM was born, as he himself writes, in the year 1494, in a village in *Switzerland*, call'd *Hoenheim* (q. d. *ab alto nido*) two miles distant from *Zurich*. His father was a natural son of a great master of the *Teutonic* order, and had been brought up to medicine; which he practis'd accordingly, in that obscure corner. He was, it seems, master of an excellent, and copious library; and is said to have become eminent in his art; so that *Paracelsus* always speaks of him with the highest deference, and calls him *laudatissimus medicus in eo vico*. Of such a father did *Paracelsus* receive his first discipline.

After a little course of study at home, he was committed to the care of *Trithemius*, the celebrated abbot of *Spanheim*, who had the character of an adept himself, and wrote of the *Cabbala*: being by many reputed a magician. Here he chiefly learnt language and letters; after which, he was removed to *Sigis. Fuggerius*, to learn medicine, chirurgery, and chemistry. All these his masters, and especially the last, *Paracelsus* ever speaks of with great veneration: So that he was not altogether so rude and unpolish'd as is commonly imagined. Thus much we learn from his own writings; and especially the preface to his *lesser chirurgery*, where he defends himself against his accusers.

At 20 years of age, he undertook a journey throughout *Germany*, and *Hungary*; visiting all the mines of principal note, and contracting an acquaintance with the miners and workmen; by which means he learnt every thing relating to metals, and the art thereof. In this inquiry he shew'd an uncommon assiduity, and resolution: He gives us a frightful account of the many dangers he had run from earthquakes, falls of stones, floods of water, cataraets, exhalations, damps, heat, hunger, and thirst; and every where takes occasion to insist on the value of an art acquired on such hard terms.

The same inclination carried him as far as *Muscovy*; where, as he was in quest of mines, near the frontiers of *Tartary*, he was taken prisoner by that people, and carried before the great *Cham*: during his captivity there, he learnt divers secrets; Till, upon the *Cham's* sending an embassy to the Grand...

Grand Signior with his own son at the head of it; *Paracelsus* was sent along with him in quality of companion. On this occasion he came to *Constantinople*, in the 28th year of his age; and was there taught the secret of the philosopher's-stone, by a generous *Arab*, who made him this noble present, as he calls it, *Azoth*. This incident we have from *Helmont* only; for *Paracelsus* himself, who is ample enough on his other travels, says nothing of his captivity.

Improves on the
medicinal prac-
tice of those times.

At his return from *Turky*, he practised as a chirurgion in the imperial army, and perform'd many very notable cures therein. Indeed it can't be denied but he was excellent in that art; of which his *great chirurgery* printed in *folio*, will be a standing monument. At his return to his native country, he assumed the title of *utriusque medicina doctor*; or doctor both of internal, and external medicine or chirurgery; and grew famous in both; performing things far beyond what the common practice of that time could pretend to. And no wonder: for medicine was then in a poor condition: The practice, and the very language was all *Galenical*, and *Arabic*. Nothing was inculcated but *Aristotle*, *Galen*, and the *Arabs*; *Hippocrates* was not read: Nay, there was no edition of his writings; and scarce was he ever mention'd. Their theory consisted in the knowledge of the four degrees, the temperaments, &c. and their whole practice was confined to venesection, purgation, vomiting, clysmata, &c.

Now in this age a new disease had broke out, and spread itself over *Europe*; viz. the venereal disease: The common *Galenic* remedies had here proved absolutely ineffectual: Bleeding, purging, and cleansing medicines were vain; and the physicians were at their wit's end. *Jac. Carpus*, a celebrated anatomist and chirurgion at *Boulogne*, had alone been master of the cure; which was by mercury administred to raise a Salivation: He had attain'd to it in his travels thro' *Spain* and *Italy*, and practised it for some years, and with such success and applause, that it is incredible what immense riches this one *nostrum* had brought him in: he owns himself, that he did not know the end of his own wealth; For the merchants, governors, commanders, &c. who had brought that filthy disease from *America*, were content to give him what sums he pleas'd to free 'em from it.

Attains to the use
of mercury.

Paracelsus, about this time, having likewise learnt the properties of mercury; and, as 'tis probable, from *Carpus* too, undertook the same cure, but in a different manner: For whereas *Carpus* did all by salivation; *Paracelsus*, making up his preparations in pills, attain'd his ends in a gentler manner. By the same medicine he tells us, he cured the itch, lepra, ulcers, *Neapolitan* disease, and even gout; all which were incurable on the foot of the popular practice: And thus was a basis laid for all his future fame.

Made professor
at Basil.

Paracelsus thus furnish'd with arts, and arrived at a pitch of eminence beyond any of his brothers in the profession, was invited by the curators of the university of *Basil* to the chair of professor of medicine and philosophy in that university. The art of printing was now a new thing; the taste for learning and arts was warm; and the magistracy of *Basil* were very indus-
trious

trious in procuring professors of reputation from all parts. They had already got *Desid. Erasmus*, professor of theology; and *J. Oporinus*, professor of the Greek tongue: and now, in 1527, *Paracelsus* was associated; in the 33d year of his age.

Upon his first entrance on that province, being to make a public speech before the university, he posted up a very elegant advertisement over the doors, inviting every body to his doctrine. At his first lecture he procured a fire to be brought in a brazen vessel, into the middle of the school; where, after casting in sulphur and nitre, in a solemn manner, he burnt the writings of *Galen*, and *Avicenna*: alledging, that he had held a dispute with them in the gates of hell, and had fairly routed and overcome them. And hence he proclaimed, that the physicians should all follow him; and no longer call themselves *Galenists*, but *Paracelsists* *.

Burns the writings of Galen and Avicenna.

While he was here professor, he read his books, *de Tartaro*, *de Gradibus*, *de Compositionibus*, in public lectures; to which he added a commentary on the book *de Gradibus*: all these he afterwards printed at *Basil* for the use of his disciples; so that these must be allowed for genuine writings. About the same time he wrote *de Calculo*; which performance *Helmont* speaks of with great approbation.

His lectures.

Notwithstanding his being professor in so learned an university, he understood but little *Latin*; his long travels, and application to business, and disuse of the language, had very much unqualify'd him for writing, or speaking therein: and his natural warmth, and arrogancy, render'd him very unfit for teaching at all. Hence, tho' his auditors and disciples were at first very numerous, they fell off, and left him to preach jargon to the walls. In the mean time, he abandoned himself to drinking; and, by degrees, commenced such a thorough sot, that *Oporinus*, who lived with him, and was always at his elbow, assures us he was never sober; but kept tippling on from morning to night, and from night to morning, in a continued round. By such means he soon became weary of his professorship; and, after three years continuance therein, relinquished it: pretending, that no language beside the *German* was proper to reveal the mysteries of chemistry in.

His pupils deserting him, turne sot.

After this, he betook himself again to his itinerant life; spending his whole time in travelling, and drinking, and living altogether in taverns, and inns, continually flush'd, and loaden with liquor; and yet working many notable cures in his way. In this sordid manner did he pass four years, viz. from the 43d, to the 47th year of his life; when he died, as he lived, in an inn, at *Salzburg*, at the sign of the white horse, on a bench, in the chimney-corner. *Oporinus* relates, that after he had put on any new garment, it never came off his back, till it was wore to rags. He adds, that notwithstanding his excess in point of drinking, he was never in the

His death.

* "Know, physicians," says he, "my cap has more learning in it than all your heads; my beard has more experience than whole academies of you: *Greeks, Latins, French, Italians*; I will be your king."

least addicted to venery. But there was a reason for it: it seems, when he was a child, being neglected by his nurse, a hog fell in his way, which bit off his testicles, and so made an eunuch of him. Accordingly, in his writings, he omits no occasion of railing against the women.

Such was the life of *Paracelsus*; such was the immortal man, who, sick of life, retired into a corner of the world; and there supports himself with his own *Quintessentia Vita*. We now proceed to his books; and his pretensions to the grand *arcana* of alchemy.

His writings.

In his life-time, we have already observed, he only published three, or four books. But after his death, he grew prodigiously voluminous; scarce a year passing, but one book or other was published under his name; said to be found in some old wall, ceiling, or the like. All the works father'd on him were first published together at *Strasbourg* in the year 1603, in three volumes *in folio*; and again in 1616. These editions are both in *High-Dutch*; on which account they are preferable to the rest, as the books were all originally composed in that language. But in both these editions, the 10th book, *de Archidoxis*, is wanting; which is, as it were, the key of all the rest. In the year 1658, all the three volumes were published at *Geneva*, translated into *Latin*; with the addition of the 10th book, so much wanted in the former.

J. Oporinus, that excellent professor and printer abovemention'd, who constantly attended *Paracelsus* for three years as his menial servant, in expectation of learning some of his secrets; who publish'd the works of *Valerius*; and is supposed to have put them in that elegant language wherein they now appear: this *Oporinus*, in an epistle to *Monavius*, concerning the life of *Paracelsus*, professes himself surprized to find so many works of his master; for that in all the time he was with him, he never wrote a word himself, nor ever took pen in hand: but that as he spent all his time among porters and carmen, and was eternally drunk, he would sometimes come reeling home, and, brandishing his drawn sword, force *Oporinus* to write what he dictated. But this was but little. However, *Oporinus* used to wonder how such coherent words, and discourse, which might even become the wisest persons, should come from the mouth of a drunken man.

*Many of them
suppositions.*

'Tis more than probable, then, that the bulk of the pieces published under his name, are not his; but that the other chemists, his followers, chose to usher in their performances under the sanction of his name. In effect, they are so many, and so different from each other, that 'tis next to impossible they should all come from the same hand. And yet, beside the three books which he lectured in public, there are some others that seem to have good pretensions to be genuine: such is that *de Peste*, wrote for the sake of his hosts in the east, and about *Constantinople*, from whom he had receiv'd a deal of kindnesses, and whom he had then promised a remedy against the plague: that *de Mineralibus*: that *de vita longa*: and the *Archidoxa Medicina*, which was published by *Bodensteyn*, while *Paracelsus* was living, or at least soon after his death.

This

This work is call'd *Archidoxa Medicina*, as containing the principal rules and maxims of the art. Nine books hereof were published at first: and the author in the prolegomena to them speaks thus: *I intended to have published my ten books of Archidoxa; but finding mankind unworthy of such a treasure, as the tenth, I keep it close in my occiput; and resolve never to bring it thence, till you have all abjured Aristotle, Avicenna, and Galen, and have sworn allegiance to Paracelsus alone.*

However, the book did at length get abroad; tho' by what means is not known: it is confessedly a glorious piece, and may be ranked among the principal productions in the way of chemistry, that have ever appear'd. Whether or no it be *Paracelsus's*, we will not affirm; but there is one thing speaks in its behalf, viz. its containing a great many things which have been since trump'd up for great *Nostrums*; and *Van Helmont's* lithontriptic, and alcahest, are apparently taken hence. The following passage of *Helmont* has occasion'd me much speculation: *To distil the volatile spirit of sea-salt, in order to dissolve the stone in the bladder; digest sea-salt for a month with juice of horse-radish; and then distil the whole: what rises, is the spirit of the salt; of singular efficacy in dissolving the stone either in the bladder, or reins.* I was always at a loss how *Helmont* came to know that sea-salt would ferment with radish-juice; there being no hint of the thing in any of his other writings: but my surprize was over upon reading the process in express terms in the 10th book of *Archidoxa*. So is the whole book, *Of the alcahest*, most apparently taken from the same.

Among the genuine writings of *Paracelsus*, are likewise reckon'd that *De ortu rerum naturalium*, *De transformatione rerum naturalium*, and *De vita rerum naturalium*. The rest are spurious, or very dubious at best; particularly the theological works.

It remains, that we sift his merits as to medicine, and alchemy: enquire what wonders he wrought therein; and on what ground his pretensions to the philosopher's stone, and universal remedy, stand.

This, then, must be confess'd, that an arrogant, assuming air, infected all his writings, as well as his actions. It was familiar with him to promise mighty things with compleat assurance; upon slender, inadequate grounds. Could there be a greater instance of the man's foible in this respect, than his undertaking, by the mere use of his *Elixir Proprietatis*, (a preparation of aloes, myrrh, and saffron) to prolong a man's life to the age of *Methusaleh*; and to deliberate with himself to what period he should protract his own? It argues his trusting to imagination more than experiment: for, as he died a young man himself; 'tis certain he could not have experiments sufficient to warrant any such thing; nor did he speak of his knowledge, as a physician ought to do, but purely of his caprice.

We know not how it is, but the common body of chemists both of his ^{His pretensions} and our times have complimented *Paracelsus* with the knowledge of the u- ^{to an universal} niversal remedy; and he himself is at the head of the opinion: he swears by his own soul, and calls every God in heaven to witness, that with one single remedy prepared from metals, he was able to cure all diseases, be ^{medicine.}

they stone, gout, cancer, or what they will : To hand down which opinion to posterity in the most solemn manner, it is engraven on his monument in the outer wall of the church of *Salzburg*. But for all this assurance, a man may venture to withhold his assent : His own history affords no great proofs of the thing ; nor have we any competent testimonies of other writers. *Helmont*, who knew as much of *Paracelsus* as any man living, does not believe a word of it : That author is always commending him, but warns us not to trust to him ; adding, that his writings are full of babble.

Crato, in his epistle to *Monavius*, relates, that “ upon the rumour of his great skill at the emperor’s court, he was sent for to cure the great chancellor, then laid up of the gout. *Paracelsus* undertook the cure ; and promis’d a very speedy recovery, on condition all the other physicians should be set aside. But after several weeks spent in vain, the patient rather going backwards every day ; finding the most powerful of his remedies ineffectual, he slipt privately away, and cou’d never by any words or promises be brought to court again *.” *Borrichius*, who so warmly maintains him a master of all the arcana aim’d at by alchemists, would find somewhat to do, to give a reason for his failure in this instance : again, *Crato* adds, that being at a consultation with *Paracelsus*, *Crato* ask’d him why he cough’d, when he had so noble a remedy in his hands ? to which *Paracelsus* answer’d, *I cou’d soon cure myself, were it not for this ; at the same time taking up a cup of wine.*

But what effectually overthrows his pretensions to such a remedy, is his own dying at an immature age. When at *Salzburg*, finding his days near a period, he sent for a notary to make his will ; which is still preserv’d by the magistrates of the place. The same notary attests, that he found *Paracelsus* on his legs, and perfectly sensible ; only very weak and languishing : If he had any notion of an universal remedy, this certainly was the time for it. As to what is objected from his epitaph, it will have no great weight ; in these monumental inscriptions, we all know how little regard is had to historical truth.

His real merits.

The great fame and success of the man, which with some passes as an argument of his being possess’d of the secret ; is easily accounted for from other principles. ’Tis certain he was acquainted with the use and virtues of *opium*, which the *Galenists* of those times all rejected as cold in the fourth degree : *Oporinus* relates that he made up a sort of little pills of the colour, figure, and size of mice-turds ; which were nothing but *opium*. These he call’d by a barbarous sort of name, his *laudanum*, *q. d.* laudable medicine ; he always carried them with him, and prescribed ’em in dysenteries and all cases attended with intense pains, anxieties, deliriums, and obstinate wakings. But to be alone possess’d of the use of so extraordinary and noble a medicament as *opium*, were enough of itself to have render’d him sufficiently famous.

* The same *Crato* tells us, that *Paracelsus* being sent for to the emperor, who was dangerously ill, he took a pill out of the pommel of his sword, which succeeded so well, that the emperor went a-hunting the next day.

Another

Another grand remedy which *Paracelsus* had to himself, was *Turbith Mineral*. This is first mention'd in his *Clein Spital Boeck*, or *Chirurgia minor*; where he gives us the preparation. "Take, says he, mercury, mix it up with thrice the quantity of oil of virriol; precipitate, and wash it with water, and you will have a yellowish powder; distil it with spirit of wine, and administer it to the quantity of 8 grains; it will cure all the diseases above-mentioned." This is the very *Turbith* which the modern practitioners find of so much efficacy in the venereal, and almost all chronical and cutaneous diseases, where violent vomitories are required: Indeed the dose here mention'd is too large, but he durst try any thing. *Oporinus* relates, that all the time he was with *Paracelsus*, he spent his feber hours in making his *Emplastrum opodeldoch*, and preparing *Turbith*; nor does he make mention of any other remedies.

By this time we have data enough to account for *Paracelsus's* mighty fame. ^{The ground of his fame.} 1°, In that he was well skill'd in chirurgery, and practis'd it with great success. 2°, That he understood the common practice of physick as well as his cotemporaries. 3°, That he was alone master of the powers, preparations, uses, &c. of metals. 4°, That he had the use of opium to himself, and wrought wonderful cures thereby. And 5°, That he was well acquainted with the virtues of mercury, in an age when no other person but *Carpus* knew any thing of the matter. These five concurring circumstances take in his whole merit; and were the matter of all his glory: the rest was empty smoke, and idle ostentation.

We have but little to say as to the philosopher's-stone, which his followers put him in possession of; 'tis certain he was at first very poor, and grew at length immensely rich. *Oporinus* says, he has frequently wonder'd to see him one day without a farthing in his pocket, and the next day full of money; and that he never took any thing with him, when he went abroad. He adds; that he would often borrow money of his companions, the carmen and porters; and pay it again in 24 hours, with extravagant interest: and yet from what fund, no body knew. In the *theatrum alchemiae* he mentions a treasure hid under a certain tree, *quem tu Pavilio, nec tu Carole unquam potestis aequare*; and from such grounds is he supposed to have had the art of making gold. But, why have recourse to so violent a machine, when a lesser will do? 'Twas hard if such noble nostrums as he possess'd, would not subsist one man; when we find what comfortable livelihoods are now got by every pitiful pretension to an *arcanum*. ^{His pretensions to the philosopher's-stone.}

'Tis certain *Paracelsus* wrought abundance of great cures, and in the same way with *Carpus*, whose wealth has already been mention'd; and it appears he knew how to ask his fees: Witness the poor Canon's case, who being severely handled by the venereal disease, *Paracelsus* refused to undertake his cure, but on promise of a huge reward; the cure was accordingly wrought by a salivation; but the Canon finding how soon 'twas done, and with how few medicines, refused to give the stipulated reward. *Paracelsus*, hereupon, in a rage brings him before a court of justice; with loud outcries demands the judges to order the payment; and upon their declining;

History of CHEMISTRY.

declining it, pursued 'em with all the reproaches and railing, his spleen could suggest. A man thus provided, one would think, might make a shift in the world, without the philosopher's-stone to help him out.

VAN HELMONT, the greatest and most experienced of all the chemists that have yet appear'd, succeeds *Paracelsus*; 'twas he put the finishing hand to what his predecessor had but begun: viz. the introducing of chemistry into medicine. He was originally, and by profession a physician; but wrought such a change in that art upon his taking to chemistry, that nothing at length could go down in *physic*, but what was thoroughly *chemical*.

The fate of chemistry, and the idea we are to form thereof, has a considerable connection with that of the life, writings, and pretensions of this memorable person: So that they will deserve to be thoroughly discuss'd. To prepare myself to give you the more satisfaction on this head; beside perusing all his writings with great attention, I have made industrious inquiry about *Brussels*, *Wilword*, and *Bois le duc*, the places where he spent the greatest part of his life; and have got intelligence which may guide us in forming a judgment of him.

History of Van
Helmont.

JOHN BAPTISTA VAN OR AB HELMONT, was born at *Brussels*, in the year 1557, thirty-six years after the death of *Paracelsus*. He was descended of a noble family, which took its denomination from a little village call'd *Helmont*, in the neighbourhood and district of *Sylva ducis*, or *Bois le duc*.

His proficiency in
the school learning.

At three years of age he lost his father; and as he was the youngest born of a numerous family, not having much fortune left him, he applied himself to his studies. At proper years he was sent to the university of *Louvain*; where he studied mathematics, and particular algebra, which he made great proficiency in, and became eminently versed in all the doctrines thereof. He then applied himself to the Schools, i. e. to the discipline of *Aristotle* and *Galen*, which was the reigning study at that time at *Louvain*; at length he turn'd himself to medicine, which he learnt under several professors, particularly *Fortunatus Vopiscus*, *Plempius*, &c. and with such success, that at seventeen years of age, he was thought qualified to teach *physic*; and, accordingly, was appointed *praelector* thereof, according to the custom of the regents, and professors of that age, who generally chose the most learned among their disciples, to give public lectures to the rest.

Commences doctor
of physick.

Thus did *Helmont* give his lectures of medicine, tho' some say only of *chirurgery*; and so far did he here go, till he was promoted to the degree of doctor in the faculty. This we learn from his own writings; and yet in other places he denies he ever was created doctor; but he is not there to be understood in the strictest terms: For that he did take the degree, and in the year 1559, is certain; and there is a register thereof still extant among the acts of that university. His reason for suppressing the knowledge of his doctorate, was, in his own words, *ne imperiti homines dicerent se peritum promovisse, habuit enim imperitos professores*; lest ignorant unskilful persons, such as he esteem'd the professors, should have the credit of promoting one so well skill'd as himself.

While

While he was here, he assures us he read over *Galen* twice; and *Hippocrates*, and all the *Arabs*, and *Greeks*, once; and this before he arriv'd at twenty-two years of age: so that he had laid in an ample stock of the learning, and arts of those days, e'er he came to chemistry.

Now that he had gone through his course of studies, and was arriv'd at the doctorate; he enter'd upon the practice of physick: but his first successes came vastly short of his expectation. This put him strangely out of humour with the art; which another incident, about the same time, help'd to confirm. It happen'd, thro' some extraordinary familiarity with a maid of quality, that he caught the itch: upon this, his brothers of the profession were applied to, to help rid him of so filthy a disease. He told them what measures he had already taken; that he had open'd a vein, had taken scammony, &c. and they applauded every step; ordering him, withal, a dietetic decoction. But all was in vain; the disease kept its hold; and the whole faculty was baffled. Hence, he began to be in doubt, whether physic had any foundation in nature. *Falls in the practice of physick.*

Under this mortifying uncertainty, he resolv'd to sell all his books, and dispose of his effects; and travel'd about from place to place, to inform himself better; and learn what there was further to be known. He had here time for reflection, and began to think it a judgment on him, for running so eagerly after medicine; contrary to all the intreaties, and remonstrances of his friends, and relations. Thus unhappily did his days pass, the space of ten years; when, about the 33d year of his age, he accidentally met with a *Paracelsian* chemist. Upon a conversation between them, the chemist aver'd he could do more with one or two of his chemical preparations, than the *Galenists* with all their stock; and that *Paracelsus* had done more than all the other physicians put together. For a proof, he cured him of his itch by means of sulphur; and shew'd him some other experiments. *Begins to doubt the foundation of the art.*

The abandon'd physician began now to take heart again: this new light soon alter'd the course of his thoughts; and to chemistry he falls with all his might. In order to this, he retir'd to *Wilword*; where he lived a long time, in great ease, and tranquillity, out of all road of his friends, and acquaintance, wholly taken up in chemical operations, night and day. *Takes to chemistry.*

Here, with unwearied labour, he examined the whole tribe of bodies, both foffile, vegetable, and animal, by the light of chemistry; and thus, first furnish'd a new body, or course of chemical knowledge. Here it was he made those noble experiments, and discoveries, of oil of sulphur *per campan.* the *Laudanum Paracels.* *Acidum hostile*, &c. spirit of hart's-horn, spirit of human blood, *sal volatil.* *oleos.* &c. *His experiments and discoveries.*

To look back a little: he had of many years been a master of the philosophy of that age, which consist'd wholly in words, without facts, or experiments; he was now become deep in chemistry, which is all experiment, and no sound; and he had before attain'd the *Galenical* medicine, and that of the *Arabs*, which turn wholly on the four elements, four humours,

mours, and four qualities, and uses few other remedies beside phlebotomy, purging, and *Camharides*.

Reduces all medicine to chemistry.

Now, a man of his genius, and views, seeing so many more powerful remedies produced by chemistry; naturally enough began to imagine, that all might be true. *Paracelsus* had advanced; and thus took the contrary byals, run counter in every thing to the *Galenic* school, banish'd every thing of that kind out of medicine; and reduced the whole art to principles of chemistry. He tells us he had long observ'd the impertinence of the school-doctrine, both in philosophy and medicine; and that it was only fit for talk, not action: in which sentiment he was follow'd by the great lord *Versulam*, who every where stiles the peripatetic school *Logodadala*, as talking a deal about the nature of things; but handling nothing.

His writings.

With such views he began to write: his first production was of ** spaw-waters*, printed at *Liege* in 1624, and procured him a world of esteem. There are abundance of good things in it, and but little of that opinionativeness, and boasting, which shew'd itself in his later works: he had it reprinted the same year at *Cologne*, with new experiments. In 1644 he published his second piece, *Of the humours* †, against the humourists; a third, *Of fevers* ††; and a fourth, *Of the stone* ††: which are all the books he published in his life-time.

Soon after the publication of the last, he died, viz. in the same year 1644; on the last day of the year, and the 67th of his life. So that what has been suggested by some eminent chemists, viz. that *Helmont* had changed his sentiments, and had got quite other things in view, e'er he died, appears without any ground; as he lived but a little while after finishing the last, and all that time continued indisposed.

He was very sober, and regular in his way of living; of a firm body, and a healthy constitution. His way of writing is very entertaining: and his style, tho' not always pure *Roman*, yet never fails to be elegant.

We have been assured by persons who knew *Helmont*, and conversed with him, that he was scarce known in his neighbourhood; that he did not apply himself to practice; nor scarce ever stirr'd out of doors: only, a few of his next country neighbours, he used to give his advice to, gratis. He had been invited to the emperor's court; as also to that of the Elector *Palatine*, in quality of chymist, and physician to those princes; but he declined both.

Death.

As he perceived death drawing nigh him, he call'd his son, *Fr. Mercury ab Helmont*; and gave him the following charge: "Take all my writings, the crude as well as the finish'd ones; and join them together: to your care I commit them; do with them what you think good. For so it has pleas'd almighty God, who directs every thing to the best purposes." This son, with whom the deposit was left, was a person of deep thought, and meditation; but a little tainted with enthusiasm; and in his father's life-time had strolled about with a gang of gypsies. After the father's de-

* De aquis spadanis.

† De humoribus.

‡ De febribus.

†† De lithiasi.

cease, he acquitted himself of the trust, by collecting all his pieces together, and publishing them just as he found them, without any regard to order, consistency, or correctness; and beside, trusted the impression principally to the printer: so that we frequently find *Helmont* relating things in one place, which he contradicts in another.

Indeed, 'tis no wonder we don't find the same tenor throughout; for, as chemistry grew under his hands, and as a world of new views must turn up in the course of forty years, which he spent in gradually improving the art; 'tis easy to conceive how there should arise a difference between the first, and last. The first, faint attempts of a raw, unexperienced novice; may well be allow'd to differ from the solid productions of a veteran, like *Helmont*.

Those he published himself, are all excellent: that *de Lithiasi*, is incomparable, and goes beyond any of the rest: that *de Febribus*, is a valuable work. That *de Humoribus* is certainly a fine piece: The *Galenists* are here drove out of all their holds; the doctrine of the four elements, four qualities, four degrees, and four humours, with the method of cure by tempering those degrees, are clearly and directly demonstrated to be false, and insignificant. The book *de Peste*, which is one of the posthumous pieces, has a deal of good things; tho' it does not come up to the merit of the former. But the rest are all so much inferior, that one would never suspect them to have come from the same hand.

The best edition is that of *Amsterdam*, in quarto, apud *Elzevir*. In the *Venetian* edition in folio, there are are a good many pieces, not *Helmont's*. And the same may be said of the edition lately published in *Germany*.

It remains, that we consider a little, what judgment shall be form'd of the man; and, particularly, as to his pretensions to the universal remedy.

He himself protests, in the most awful manner, in presence of Almighty God, and as he expects mercy at his hands; that he has a single remedy wherewith he can cure all diseases, without any kind of evacuation, and merely by correction, or alteration. This, we find, not in one place only; but something like it is inculcated in almost all his writings. A physician, he says, who cannot cure the lepra, radically, is not worthy the name of a physician.——A physician, who cannot cure all fevers by one potion of a simple diaphoretic, does not deserve the appellation.——Let every one, who cannot cure all diseases with the alcahest of Paracelsus, be expel'd the faculty——And the like.

But his notion of the origin, and foundation of an universal remedy, is very peculiar, and favours of that enthusiasm which was a part of his character. No poison, says he, can act on a carcass: if, therefore, it have any effect, 'tis by means of life; which life he calls *archæus*; and ascribes both understanding, and knowledge thereto. If now any heterogeneous body happen to be present to the *archæus*; it rises into a fervour, endeavours to expel the hostile matter; and, in order to that, exerts all the force of the body. To cure any disease, therefore, is to pacify, and compose

pose this *archæus*. This *archæus*, he holds, is irritated at the least appearance of any thing heterogeneous : and as its office is to watch over the health, and safety of the whole body ; it is excited at the very shadow of the enemy, calls its forces to the charge, raises fevers, and destroys the whole body. The thing required, therefore, is such a remedy as may readily pacify, and lay this unnatural fervour upon all occasions : and this is the universal remedy.

This doctrine of *Helmont* would not be so absurd, did not he ascribe understanding to his *archæus*. Setting this aside, the principle which renders poisons deadly, and remedies beneficial, is the circulation of the blood. No doubt but *Helmont* was apprized of this before he died. For *Harvey* had published his discovery some years before ; which *Helmont* could not but fall into : tho' he might chuse dissembling the matter, in regard it untwisted a good part of his system ; which he might want leisure, or inclination to reform, and work a-new.

He adds, that *Adam*, had he retain'd his innocency, would have lived for ever ; inasmuch, as he would have fed of the tree of life, growing in *Paradise* : but that, upon his fall, God removed the tree of life, and hid it in the heart of metals. If, therefore, we can any how extract it out of the same ; we shall stand the same chance for immortality as *Adam* did.

Now, whether *Helmont* had any such remedy, or tree, as he pretends, is the point to be consider'd : if he had, we must certainly find some instance of the use, and effect thereof.

Vanity of his pretensions.

He had three sons ; two of which, he owns, he could not cure of the plague, but lost them both : and yet in his book *de Peste*, he expressly declares he could cure the plague, and all other diseases.

Again, he had a daughter seiz'd at five years of age with a slight leprosy, which afterwards produced livid ulcers, and dry horny scales over her whole body : he attempted her cure for two whole years successively ; but in vain : and yet he is continually boasting, that the *alcahest* cures the *lepra* immediately ; and he swears by the immortal Gods, that he is master of the *alcahest*. However, instead of applying it, he sent his daughter to the image of the virgin *Mary*, in the hospital of *St. James* : from whence, he ingenuously owns, she returned back, perfectly sound, in an hour's time.

Butler's stone.

His wife, too, had been sick for some time. He did what he could to recover her ; but she laugh'd at him, as not capable of the cure : nor did all his endeavours avail a straw. It happen'd, about the same time, that *Butler*, the famous *English* physician, was clap'd up in prison for counterfeiting the coin ; and *Helmont* was sent for to *Brussels*, to be an evidence. Here he contracted an acquaintance with *Butler* ; and seeing him perform several extraordinary cures with his stone, he ask'd *Butler* how he came by the secret : *My dear*, answers *Butler*, laughing ; *unless you arrive at the cure of all diseases by a single remedy ; you'll be but a novice, tho' you should live to the age of Methusalem.*

At

At his return home, *Helmont* told his wife he had now got her remedy; and that she was to be cured by *Butler's* stone. Accordingly, the stone being steep'd in oil of olives, and the oil applied on the part affected, she recover'd to a miracle.

Let us now see how he managed his own body, when out of order. If neither his sons, daughter, nor wife were dear enough to him, to make him apply his remedy; yet sure he would not have grudged it on himself. In page 322 of his works, he writes thus: "On the 27th of *December*, "in the sixty-third year of my age, I was suddenly seiz'd with a slight "fever, attended with a chilness, which set my teeth a chattering: "this was succeeded by a pungent pain in my side, and *sternum*; a difficulty of breathing; and a spitting of blood." We have here a perfect description of a genuine peripneumony, with an inflammation of the side, *pleura*, and lungs. *Hippocrates* would here have directed him to forbear letting blood; and to have immediate recourse to demulcent remedies. Let us now see what course he really took, and what universal remedy was applied on this perillous occasion: "I immediately took scrapings of "the *penis* of a goat, reduced to powder; and the pain vanish'd;" [but the disease continued.] "The next day, I drank a drachm of goat's blood; "by which, in three days time, the *sputum sanguinis* disappear'd: but "there still remain'd a little cough;" [for he was not yet cured, nor the matter of the disease carried off.] "This stuck fast by me, accompany'd "with a difficulty of breathing, a continued fever, and intermitting pulse. "At length, I felt a pain in the spleen: to remove which, I took a "draught of wine with *lapis cancror.* and the symptoms all disappear'd." So far was this mighty chemist from applying any chemical *arcanum*, or universal medicine; that, we see, he took none but the most contemptible *Galenical* ones: the genital of a goat, goat's blood, and *lapides cancrorum*: and this in a pleurisy, peripneumony, and pain of the spleen.

But let us see how he died: He was taken ill of an asthma, which press'd him so, that he was obliged to rise at mid-night, and fetch his breath out at the window. This disease he could not cure; but let it degenerate into a *vomica pulmonis*. His son adds, that he died under a slight suffocation, and *deliquium*, perfectly sensible, and apprehensive of the approach of death. It were needless to ask, what was now become of the tree of life? and why he died at sixty-seven years of age, with the remedy in his power?

In his treatise *de vita longa*, he asserts that cedar-wood, reduced into an *ens* by the alcahest, is that *primum natura*, one or two drops whereof absterges the matter of all disease, cleanses the blood, restores the vital juice, and revivifies a man every moment; so that with the use hereof it were impossible for him to die. What absurdity! And does not *Helmont* rave? The alcahest he swears he has; and cedar-wood is easily procured: What boots it to protract other peoples days to the longest period; and to die young one's-self?

His son *Mercury* was master of all his secrets; knew the powers of all his medicines; and all the father did, or could do: and, withal, was a person of great candour, and humanity. This gentleman, being sent for to an excellent lady, the wife of a friend of mine, who had generously entertain'd him in his house a considerable time; with a request, he would cure the lady of a disease in the stomach: he order'd her "every morning, and evening, to lick upon *Cyprus vitriol*, with the tip of her tongue:" which was all the *arcanum* he knew in such a case.

It appears, then, contrary to the unanimous voice of the whole tribe of chemists, that *Helmont* had not the universal medicine. And if these two persons, the greatest, and most famed for chemical knowledge, that ever lived; and whose pretensions, of all others, stood the fairest; were guilty of direct falshood, and deceit, in pretending thereto: it may be taken for granted, no body was ever yet master thereof.

We have taken all this pains to unravel, and clear up this mighty *mystery of chemistry*; of which so much ill use has been made; and to set the pretensions, and *arcana* of these patriarchs of the chemists on their true footing: that our reader may be prepared to obviate, and cut short the empty boasts of the common chemists, who have profited by the cloud and embarrass wherein the matter has hitherto been involved.

For my own part, after reading the writings of the two authors above-mention'd; I was at once discouraged, and cast off from all thought of ever practising physic more. For, as they assert it needless to enquire into the cause, nature, seat, symptoms, effect, &c. of a disease; or to trouble one's-self with regimen, diet, &c. since with one little, simple medicine, all diseases may be cured, alike; and death shut out from every door: I was hence struck with the utmost inquietude; and began to spend my days, and nights, in a solicitous perusal of their doctrines, and experiments, to get some opening into the secret; as never suspecting, that men, christians, scholars, artists; nay, and men of the largest minds, the finest parts, and the most extensive knowledge, and skill, the *Genii* of their age, the founders of useful arts, and the benefactors of mankind, should be guilty of such mean, premeditated falshood, back'd with all the religion of oaths, and imprecations.——But I was soon disabused: by an inquiry of some who had been personally acquainted with *Helmont*, and even of his son; I learn'd how much a warm imagination, a working, brooding head, and a spice of the spirit of enthusiasm, may do; and that he was not less ridden, and abused by his own distemper'd reveries, than his readers are by his mighty assertions.

From *Paracelsus's*, and *Helmont's* time, the number of chemists, and writers in the art, grew immensely; so that, to rehearse them all, would be endless. The art once form'd, and laid out, there was matter for infinite heads, and hands, to dispose, digest, build, pull down, teach, controvert, pursue, fill up, reduce, and apply it. Accordingly, there is scarce one art to be named, of so late a standing, that can reckon up so many authors: witness *Borelli's Bibliotheca Chemica*, printed at *Heidelberg* in 1653; wherein

wherein no less than four thousand writers, already extant, are enumerated; and yet he mentions none but those of his own knowledge. Others, who took more scope, found above double that number at the same time. It may be added, that the seventy years elapsed since, have produced more than all the ages before.

Here, therefore, we must end our career; the field is too vast to enter on. We have conducted chemistry from its rise to its state: its progress is now at an end; and the rivulet we have hitherto pursued through all its tours, and augmentations, now terminates in an immense ocean; where, if we cannot conduct you to all the coasts, and islands; we can, however, point out the principal roads, and ports; mark the rocks, and dangers; and instruct the young adventurer how he may pursue his voyage with the most security, and advantage. For chemistry is not only a dark, and intricate, but a dangerous road; and he who enters on it, must proceed, not only with address, but with circumspection, and care. That part which relates to metals, is remarkably perilous: The single vapour of arsenic may either immediately suffocate, or occasion a debility for ever after; And an author who relates an experiment, without expressing every circumstance thereof in terms at length, is not only useless, but even dangerous: 'Tis on these minute circumstances that the event of every operation depends; and an alteration in any of these, may not only prevent the success of the whole, but even render it, unexpectedly, fatal and deadly. For an instance: if in preparing *sp. nit. dul.* an author should only say in the general, *Pour the spirit of wine on the nitre, in a tall glass,* the operator would certainly be suffocated. To avoid this, it should be said, *Instil the spirit, drop by drop, under the chimney.* 'Tis not safe trying any thing, therefore, after an author, unless he be of assured accuracy, and note even all the collateral circumstances, to be guides to us.

The operations of chemistry attended with great danger.

Choice therefore to be made of the authors we follow.

To impress this the stronger; I shall subjoin an instance of the peril myself underwent: I had long entertain'd an opinion, that phosphorus might be procured from human blood: to put the matter to a proof; I took a quantity of blood, and extracted from it every thing that fire would bring away: the remainder was a thick, viscid matter: this matter I burnt with fire in a close, fortified retort, and came at midnight with a candle, to see the effect. I presently perceiv'd the neck of the retort was beginning to be stuff'd with a thick matter, which ascended from bottom to top; and foresaw the neck would soon be quite closed; and apprehended the consequence. Accordingly, I immediately withdrew; and was no sooner gone, than the ascending oil, by its elastic force, burst the vessel into a million of pieces; and in one moment set the whole room, as it were, in a flame. Had I been by, I had doubtless perish'd; either by the fragments of the glass, or the fumes of the oil; or else my respiration had been instantly stop'd by the fire.

We proceed, therefore, to chuse out the best authors; and those we would recommend for a regular study of chemistry. These we shall reduce into four classes.

These authors reduced to Classes.

The

Systematical authors.

The first class includes the *systematical* writers, or those who have collected all the known things, i. e. all the operations in chemistry into a body, and digested them in form and order of an art or institution, for others to learn by; commonly with some addition of their own reasonings at the end of each operation. Of these,

Beguinus.

JOHANNES BEGUINUS claims the first place, for his * *TYROCINIUM CHYMICUM*. The book is in 12^o, and has been often reprinted, with notes by several hands.

Crollius.

OSWALDUS CROLLIUS comes next, on account of his † *Basilica Chymia*. He was a physician of great learning, the emperor's chemist; and a strenuous adherent of *Paracelsus*, whose pupil he had been. *Hartman* has wrote a comment on him, under the title of *Hartmanni commentatio in Basilicam chymiam*, wherein are abundance of cautionary rules; and the operations every where exactly described. The work is in 8vo; it is also found among *Hartman's* works in folio.

Glaser.

GLASER, a chemist in the court of the *French* king, succeeds. He wrote a *French* treatise in 12^o, entitled *Traite de la Chymie*, wherein the circumstances of the processes or operations, are briefly and faithfully described.

NIC. LE FEBURE, or FEVRE, by nation a *Dutchman*, flourish'd in the courts of *England* and *France*, as chemist to king *Charles II.* and *Louis XIV.* He publish'd a book in *French* under the title of *Traite de la Chymie*, in two volumes in 8vo; afterwards in 12^o, which latter is to be prefer'd. He is highly to be valued and commended, as both delivering the whole art, with all the processes; and as he every where precisely notes all the minutest circumstances. No body is more faithful and accurate in the accounts of his experiments; he is particularly careful to note all the dangerous and deadly processes: But he has this defect, that in his reasonings he has too much of the chemical spirit; and talks too largely of the virtues of his medicines.

Mr. *Boyle* quotes him under the characters L. F. and mentions his *Ess primum* of balm, whereby he pretended to restore youth and vigour to old worn-out animals.

Lemery.

LEMERY the elder, a celebrated member of the royal academy of sciences, and chemist of the late king *Louis XIV.* has given us an excellent work in *French*, entitled *Cours de Chymie*. The best edition is that of *Paris* in 8vo 1713, which has many things not in any of the precedent ones. It contains all the principal operations belonging to the three kingdoms; all which are described with great candour, and no less accuracy. To each are added scholia or notes, containing the physical reasons thereof. He is every where minute in enumerating all the circumstances of the processes, and particularly where any danger might arise ||.

Jo.

* Novitiate or Apprenticeship of chemistry.

† Royal Chemistry.

|| *Monf. Lemery*, who makes so great a figure among the modern chemists, was born at *Rouen*, in 1645. His first notion of chemistry he got from an apothecary of the place, to whose discipline he was committed; but soon perceiving it must be another-

JO. CONR. BARCHAUSEN, professor of chemistry at *Utrecht*, deserves Barchausen.
well to be read. He is an honest writer, and sufficiently accurate; he delivers good matter in an excellent style, tho' his reasonings are not so much to our mind. His *Elementa Chemiæ* are printed in 4to, and contain a great many particular experiments, and manual operations, nowhere else to be met withal.

another-guise science than what his master knew, he went to *Paris* in quest thereof. Here he applied himself to *Monf. Glaser*, demonstrator of chemistry in the king's garden; but finding his second master full of obscure notions, and yet a niggard of such notions as he had, he resolved on a tour thro' the kingdom, to learn what he could get from the chemists abroad. At *Montpellier* he made a stay of three years; and being now pretty well furnish'd, he could give lectures; and undertook to practise physic. In 1672, after a peregrination of six years, he return'd to *Paris* an accomplish'd chemist; and exhibited his first course of chemistry in the laboratory of his friend *M. Martin*, apothecary to the prince of *Conde*. Animated with the success hereof, he enter'd himself in the company of apothecaries; and open'd a laboratory of his own in the *Rue Galande*, where he perform'd courses with infinite applause, all the virtuoso's of *Paris* resorting to his cave. Foreigners soon flock'd in apace from all parts; and *Paris* was then the seat of chemistry, whither the students repair'd, as *Leyden* is now.

His preparations were already come into great vogue; and some of his nostrums, particularly the magistery of *Bismuth*, brought him money in abundance.

The face of chemistry had till then been strangely clouded: Quaint, enigmatical terms, and imaginary sympathetic properties of bodies every where disfigured it; or, as he himself expresses it, a little truth was so dissolved in a great deal of falsehood, that it was become invisible, and the two almost inseparable. *M. Lemery* first began to dissipate the affected obscurities of chemistry; he reduced it to more simple, precise and determinate ideas; threw out a deal of the jargon, and accommodated it to the taste and philosophy of the time.

In 1675 he printed his course of chemistry, which was receiv'd with great applause. Editions succeeded editions at an unusual

rate; and it was not long e'er it made its appearance in the *Latin*, *English*, *Spanish*, and *High-Dutch* languages. Some of his secrets, however, he still reserved in petto; particularly a very mild emetic surer than ordinary; and a mesenteric opium, wherewith he is said to have perform'd notable cures: he is even said to have contented himself with making several of the operations more easy than they had been; without revealing the utmost degree of facility, which he was acquainted with.

In the year 1681, the religious troubles coming on, *M. Lemery*, who profess'd the reformed religion, began to share therein; being order'd to lay down his courses in a limited time. The elector of *Brandenbourg* hereupon made him an invitation, by his ambassador *M. Spanheim*, to come to *Berlin*, where he would erect a post of Chemist, on purpose for him; but he declined it; and in hopes of some connivance, perform'd courses after the time prefix'd: but the court growing more severe, he came over into *England* in 1683, and was favourably received by King *Charles II.* who gave him some hopes of a provision: But finding the effects were like to follow very slowly, if at all, he return'd to *France*, and took the degree of doctor in physic at *Caen*; hoping to be shelter'd under that quality: but the edict of *Nants* in 1685, prohibiting the practice of physic to those of the religion, he was entirely stript of all employment, and left without resource.

The good man, not able to support himself under his sufferings, determined to put an end to 'em at once; and, accordingly, embraced the roman catholic faith. Upon this, practice, courses, the sale of his preparations and peaceful days return'd in abundance. Henceforward he began to apply himself to pharmacy; and in 1697 publish'd two large volumes, entitled, one of them, *Pharmatopée universelle*, the other *Traité universel des drogues simples*.

Upon

Le Mort. **LE MORT**, professor of chemistry in the university of *Leyden*, is the last we shall mention. He goes thro' and explains every thing; but insists on a bundance of operations, which have long since been disused: his work is printed in 4to.

Metallurgic authors.

The second class contains the *metallurgic* writers: by *metallurgia* is understood the whole art of preparing and working metals, from the glebe or ore, to the utensil. This part of chemistry, therefore, is employ'd in the finding, digging, purifying, and rendering of metals malleable; and consists of four parts: The 1st teaches how metals grow in the mine, how they are discover'd, and how procured out of the same; the 2d how to separate the metallic from the other matter of the ore; the 3d how to reduce the separated metal to its simplicity, and ductility; and the 4th to work, gild, polish, and imitate the finer metals in the coarser. Among the authors to be read herein,

Agricola.

JOH. AGRICOLA deserves the first place, the author of a treatise *de Re Metallica*, reprinted a great number of times in folio. This work is a proof of the author's extraordinary learning and experience: by visiting all the mines, and conversing freely with the miners in *Germany*, he got a thorough knowledge of the whole process of metals; and from him most of the following writers have taken the greatest part of what they know. He wrote with the exactest fidelity, and in an elegant *Roman* style; so that we consult him as we would an oracle, upon all occasions.

In the first part of the *metallurgia*, or the discovery of metals, he is the only author; he describes with great accuracy and minuteness, all the arts and instruments made use of to discover mines, and to know whether in any given glebe, there be metal, and of what kind. Nor is he defective in any of the other parts. Several authors have wrote comments on him; but he is clear enough without any—The best edition is that of *Frankfurt*, containing a treatise *de Re Fodinaria*, after that of *Metals*.

Ercher.

LAZARUS ERCHERUS, OF AB ERCKEREN, deserves the second place. He was superintendent of all the mines in *Germany*, *Hungary*, *Transylvania*, *Tyrol*, &c. to three emperors; whence he was furnish'd with a compleat stock of metalline knowledge.

He shews by what signs to know where metals are; then, how the veins are to be open'd; how dug; how separated; purified by mercury, cementation, &c. He is really an experienc'd candid, and honest writer; he relates nothing but what he had himself seen, without a word of theory or reasoning; and every where speaks as if he were actually sitting before the furnace, and relating what pass'd.

Upon revival of the royal academy in 1699, he was elected *associate chemist*, and e'er the end of the same year, upon the death of *M. Bourdelin*, *pensionary chemist*. He then enter'd on a great work, which he read to the academy *piece-meal*; and at length publish'd together; viz. the *Traité d'antimoine*, wherein that important mine-ral is turn'd and tortured by dissolutions, sublimations, distillations, calcinations, &c. a thousand ways, and into a thousand forms, with regard both to medicine and philosophy. From this time he began to droop under old age; surrendered his place of pensionary in favour of his son, and died of an apoplexy, in 1715.

His

His way is thus: In *Hungary* there is such a mountain; wherein you have such an Earth; beat or grind it into powder, and wash it in water, and it will be of such a colour, smell and weight; and will contain so much gold, so much silver, so much copper. In such manner he teaches how it is to be exposed to the fire, and how burnt; what rules and signs are to be observed therein; how the fire is to be rais'd or diminish'd, &c.

He never fails enumerating every circumstance; and always in the most open artless manner; and in a clear, obvious style; adding figures, for further illustration: His book was wrote in *High-dutch*; and printed in *folio*: and of such value is it held among the curious, that Mr. *Boyle* laments his not understanding that language, merely for the sake of reading this author. But it has since been translated into *Latin*, with excellent notes; so that this single work might almost suffice for the whole art of metals.

The number of writers in the *metallurgia*, is almost infinite; the greatest part of *Borelli's* 3000, are of this Class: But the practical writers most of 'em take their matter from those two above mention'd; and the rest have little more than speculation, and theory. However, it may be proper to distinguish.

JO. RUDOLPH. GLAUBER, a celebrated chemist of *Amsterdam*, accounted *Glauber*. the *Paracelsus* of his time. He had travel'd much, and by that means attain'd to a great many secrets. He wrote above 30 Tracts; in some of which he acted the physician, in others the adept, and in others the metallist. He principally excell'd in the last capacity; and yet, even here, he comes short of *Agricola* and *Ercher*, in point of fidelity, simplicity, and exactness; being ever forward to mix his own speculations, and reasonings along with the matters of fact.

He was a person of easy, genteel address; and beyond dispute well versed in chemistry; being author of the salt still extant in the shops under the title of *Sal Glauberi*; as also of all the salts by oil of vitriol, &c.

He is noted for vaunting and extolling his arcana and preparations; and is even said to have traded a little unfairly with his secrets: The best of 'em he wou'd sell at excessive rates to chemists, and others; and would afterwards sell 'em over again; or make 'em public, to increase his fame: Whence he was continually at enmity with one or other.

The principal of his writings are *de Furnis*, and *de Metallis*; which tho' wrote in *Dutch*, have been translated into *Latin*.

It was this *Glauber*, who shew'd before the States of *Holland*, that there is gold contain'd in sand; and made an experiment thereof to their satisfaction: But what *Pliny* said of *C. Caligula*, *ars detrimento erat*, obtain'd here likewise; so much lead, fire, and labour being employ'd in procuring it; that the art would not bear its own charges*. However, he shew'd pretty

*His experiment
before the States
of Holland.*

* *Siball*, however, thinks, it might still it is silver, sand, and litharge; and the silver does not waste in the operation, but is turn to account; the process is very simple, and takes up little time. All they use in refined thereby.

plainly, that there is no earth, sand, salt, sulphur, or other matter ; but has its share of gold.

Geber the *Arab* above-mentioned, has many excellent things relating to the art of metals ; but he is too full of the philosopher's-stone, and considers metals too much with a view to their exaltation.

Paracelsus has something on the same subject ; but written in such a manner, that it is not easy to be understood.

Writers in al-
chemy.
Several branches
of alchemy.

The third class contains the *Alchemists*, or those who teach the art of converting baser metals, into more noble. Alchemy may be divided into three branches : The first shews how to *separate* the glebes, or corpuscles of gold contain'd in other metals : The second how to *digest* and *ripen* the crude, imperfect matter of gold in other metals : The third, to *transmute* or convert one metal into another. The first part belongs to the *metallurgia* : The last is employ'd in search of the *philosopher's-stone*, - i. e. a powder, a little whereof cast into a quantity of any metal in fusion, converts it all into pure gold. Not contented with this, the alchemists will needs carry this last part much farther : viz. To the finding of the *philosopher's ferment*, a matter which being pour'd on gold, converts it into the philosopher's-stone.

The road to fame by the way of alchemy, is very slippery and hazardous. The candidates hereof, instead of the immense riches the art promises, are frequently rewarded with the extremest indigence ; and plentiful fortunes often have been squander'd away in the pursuit. This, however, we venture to say, that no man, who has a tolerable knowledge of alchemy, can spend much money therein. The principal occasion of expence, arises hence, that those who pretend to teach the art to others, or to attain, and practise it for 'em ; fraudulently require a deal of gold and silver, as necessary in the operation * : But the truth is, an experiment is as well made with

* *Kircher* gives a long detail of the flights, and devices practis'd by the alchemists to impose on the ignorant : In all their operations they use gold, either to gild the metals they work on, or to make appear as if some part were converted. If the eye be off 'em, they will throw gold into the crucible : And if you watch 'em close, they have hollow spatula's at hand, wherein they have put gold ; so that when the matter which closed the spatula is melted, the gold drops in : They will put gold in the coals, in the bellows, or at the bottom of the crucible ; covering it over with a thin lay of earth, or the like : They disguise gold by divers preparations, and present it under such foreign forms for a secret that augments gold, and transmutes metals : They can reduce silver into less bulk ; and render it indissoluble in a

qua fortis, by saturating it with oil of vitriol ; in this disguise they play various pranks with it : They tinge vessels of gold, and silver, with the colours of iron or copper ; and by mercury restore them again : They fix mercury, and tinge it divers ways ; make nails half gold, half iron, and give the gold part the colour of iron, to have the reputation of converting it. Such a train of deceits was, probably, what put the Lawyers upon enquiry whether alchemy might not be prohibited by law ; accordingly, there is a constitution of pope *John XXII.* still extant, whereby the alchemists are decreed infamous, condemn'd to imprisonment, &c. The faculty of *Paris*, not less severe than the pope, condemn'd *Palmarius* for writing on the philosopher's-stone ; and by an arret dated the 28th of *January* 1609, injoyn'd him to abjure his error and

with a single grain of gold, as with a tonn; and whatever gold is used on such occasion, still remains gold; and may be recover'd without diminution. A man that loses a single grain of gold, does not deserve the name of an alchemist.

As to the authors on this head; 'tis hard to say that one is better than another: Since it does not appear that any of them were possess'd of the secret*. We shall therefore content ourselves to propose such, as by the consent of all ages, have been allow'd the best. These are,

ROGER

and live and die in the doctrine of *Hippocrates*; sequestering all his preferments to the use of the *Hôtel Dieu*.

But it must not be omitted that this zeal against alchemy, in some, was founded on another principle, viz. that it is impious to change any of the works of the creator.

* Whether ever there were such a thing as the philosopher's-stone, or any actual transmutation, is a point of the utmost delicacy. To prepare a man to conclude of it, a thorow knowledge of the case, and a great deal of pains and attention to it are required; but such preparation, necessary to render the conclusion safe, makes it almost impracticable to conclude at all. The common ways of judging, viz. by analogy, or from one fact, to another similar one, will not do. Many of the alchemists have been visionaries; and many of them deceivers: innumerable attempts have been vain; all this is granted: But a man that without more ado can infer the same of all the rest, is not to be trusted to make conclusions. *Morovius* in a letter to *Langelot*, relates several facts, which appear as well supported as the most authentic histories we have; But a chemist would be laugh'd at, that should plead these in behalf of the idle pretences of many of the rest.

The reasonableness and possibility of the thing, we shall hereafter have occasion to consider: Testimony is what we have now to do withal. *Helvetius*, physician to the prince of *Orange*, in his treatise, entitled *Vitulus Aureus*, affirms, that a chemist came to him, and told him that he had read some of his treatises, wherein he seem'd to question the reality of any transmutation; and that he came to shew him how well his doubts were founded. Bidding him, therefore, take a piece of a leaden

spout fasten'd to the wall of the room, and melt it; the chemist threw in a little yellow powder: Then pouring the whole upon the ground, the lead was all gold. Some time afterward he gave *Helvetius* a piece of matter about the bigness of a turnip-seed, and promis'd to see him again the next morning: But *Helvetius* wanting patience to wait his coming, cast the matter into six drachms of melted lead, which became converted into gold.

Kunkel a very sensible, discreet, and learned person, made no doubt of the existence of the philosopher's-stone; nay, he gives us proof of it, of his own knowledge: The elector of *Saxony*, he assures us, had such a tincture; and his son *Christian I.* had the same for five years after his Father's death.

I am surprized, says the excellent *Cass. Bartholin*, that people should still be in doubt whether metals may be changed into gold: I myself was witness of such a transmutation.

That curious and industrious chemist *Becher* observes, that there are so many proofs of transmutations, a man must be stupid to stand out against them. The emperor *Ferdinand III.* says he, did himself change three pounds of mercury into two pounds and a half of pure gold; and this by means of a single grain of tincture. This notable transmutation was perform'd at *Prague*; and a medal was struck of the same gold, in memory thereof. The legend on the front is, A DIVINE METAMORPHOSIS, PERFORMED AT PRAGUE, THE XVth OF JANUARY M.DC.XXXVIII, IN PRESENCE OF THE EMPEROR FERDINAND III.

We forbear to enumerate more instances, which Mr. *Boyle*, *Borrichius*, *Delrio*, &c. would furnish. We shall only add,

ROGER BACON.

RIPLEY.

LULLY.

JOHN and ISAAC HOLLANDUS.

GEBER.

BASIL VALENTINE.

PARACELUS.

Common principle
of the alchemists.

The common principle on which these authors proceed, is, that all metals consist of mercury and sulphur, so united together, as that the mercury is hereby render'd fix'd, and stable. The whole metalline nature, they hold to reside in, and depend of these two; so that the philosopher's-stone is to be sought in metals; alone tho' the two *Hollandus's*, as already observed, teach, that it may not only be made from metals, but from blood, urine, or any other thing in nature.

Van Zuchten.

ALEX. VAN ZUCHTEN or SUGTEN, a noble *German*, and a disciple of *Paracelsus*; having likewise the reputation of a conjurer: he wrote two little treatises, wherein are contain'd many of the finest, and choicest secrets of the art: The one *de Chymia*, the other *de Antimonio*. In the latter he asserts, that the philosopher's-stone may be prepared of mercury, and antimony; after purifying the antimony of all its sulphur.

In a subsequent treatise, which he calls an illustration of the former, he

that M. *Homburg* himself has actually converted silver into gold by heat alone. *Memoirs de l'Academie. An. 1709.*

It must not be omitted, that the processes described by the alchemists, not succeeding with us, is not a sufficient objection to 'em. There are infinite ways in which an experiment may fail: Air, fire, water, &c. will be shewn to have a great effect, on the operations of chemistry; and yet are all exceedingly changeable; so that the same experiment scarce ever succeeds twice exactly alike. Mr. *Boyle* is very large on the failure of experiments from differences in fire. *Van Helmont's* processes have a great many of 'em been exploded as false by later chemists, and yet have succeeded with Mr. *Boyle*. A single circumstance in a thousand is enough to untwist an operation: and as the alchemists may have been sufferers by such accidental alterations; so, no doubt, they have been gainers too. Some of their transmutations were apparently owing to some fortuitously favourable disposition in one or other of the elements, and for want of a like disposition cou'd never be repeated. Such was the case of a friend of Mr. *Boyle*, who laying some gold to digest in a

sort of aqua fortis, procured a tincture therefrom, which converted silver into gold. But after that aqua fortis was gone, he could never make more.

Hear the candid and experienc'd Mr. *Boyle* himself: he observes that such accidents often befall artists irreparably: *Glauber* tells us of several ways, by which he made gold once, but could not do it again: The prince of *Mirandola* in his treatise *de Auro* tells us of several persons whom he knew had the like success in preparing both gold and silver; And I could instance in my own acquaintance those who have once or twice made *luna fixa* (which abides the trial of aqua fortis, and only wants the tincture of gold) or some other gainful experiments, and have since in vain attempted the like, yet cannot be prevailed on to desist from their uncertain hopes. The most experienc'd mineralist I ever met with, has assured me he should quickly grow rich, could he but constantly perform what he has several times perform'd. Many experiments succeed in small quantities of matter, which fail in greater: Several projectors, and particularly chemists, have dearly bought the knowledge of this truth. *Useful. of Experiment. Phil.*

carries on the process of mercury and antimony, till gold arises therefrom ; but not pure gold : for, after having stood all the other tests, or essays ; upon amalgamating it with mercury, and laying it to digest, the whole was render'd volatile, and went off in fumes.

NIC. CENTIVOGLIO, or rather SERENUS, denominated SCORUS, deserves ^{Centivoglio,} a place in this class. *Centivoglio* was a servant, or rather companion of this *Serenus* ; who, tho' a gentleman of a good family in *Scotland*, lived a rambling life in *Hungary*, *Poland*, and other countries ; performing many surprising experiments wherever he came. When near the point of death, he call'd his friend *Centivoglio*, and intreated two things of him ; to take care of the publication of his MSS ; and to marry his widow. *Centivoglio* perform'd both ; but in the edition of his works, suppress'd *Serenus's* name, and clap'd his own in its place.

The titles of his pieces are *Novum Lumen Chemicum*, and *Dialogus de Mercurio & Alchemista*. In these he maintains with great strength of reason and experiment, that sulphur and mercury united, are the constituents of every metal : By sulphur he means, with *Geber*, the sun's rays.

In the last century, there appear'd two considerable writings in the same kind ; the one under the name of *Agricola*, the other under that of *Philalethes* : Both said to be *Englishmen*, and supposed to be originals. But upon perusing 'em they seem'd to us chiefly taken from *Van Zuchten*. Another styles himself *Pantaleo*, to whom we are indebted for two pieces, entitled *Bifolium Hermeticum*, and *Tomba Semiramidis*. He seems to have been a *German*. But the scarcest author is *Artephius* ; who if he be near so antient as is given out, *Paracelsus* and *Van Zuchten* must have taken abundance from him. ^{Agricola and Philalethes.} ^{Pantaleo.} ^{Artephius.}

Several other authors have since wrote of the subject ; the greatest part whereof, together with those already mentioned, are found in two collections printed in *Germany* ; the one under the title of *Turba Philosophorum*, in 5 vol. The other under that of *Theatrum Chemicum*, in 4 vol. in 4to, which may serve as a chemical library*.

The

* Dr. Dee, and Sir Ed. Kelley, must not be here forgotten ; who being profess'd associates, their story is best deliver'd together. They have some title to the philosopher's-stone in common fame, which in this point goes a great way ; Dee, beside his being deep in chemistry, was well versed in mathematics, particularly geometry, and astrology : but Kelley appears to have been the leading man in alchemy. In some of Dee's books are found short memoirs of the events of his operations, as *Denum Dei* 5 ounces ; and in another place, *This day Kelley discover'd the grand secret to me, sit nomen Domini benedictum.*

Astote says absolutely, they were masters of the powder of projection, and with a piece no bigger than the smallest grain of sand, turn'd an ounce and a quarter of mercury into a full ounce of pure gold ; but here is an equivoue : for granting 'em possess'd of the powder, it does not appear they had the secret of making it. The story is, that they had found a considerable quantity of it in the ruins of *Glastenbury-abbey*, with which they perform'd many notable transmutations, for the satisfaction of several persons. Kelley, in particular, is said to have given away rings of gold-wire to the value

Writers who apply chemistry to philosophy, medicine, &c.

The fourth class consists of such as have applied chemistry to the uses of natural philosophy, medicine, and other arts. The princes in this way, are,

J. B. VAN HELMONT, from whom the rest have borrowed abundance of experiments.

Boyle.

The honourable ROBERT BOYLE Esq; that prodigy of knowledge, and application, excels not less as a chemist, than as a natural philosopher. His character is one of the most amiable, and desirable in the world: No body ever made more experiments, or with more care and caution, than he; nor does any body relate the events thereof with more candour, and fidelity. He is ever exceedingly wary and reserved in drawing conclusions from his experiments; and rarely concludes too much. He held a very amicable correspondence with all the chemists, and other *Virtuosi* of his age; and thus effected a kind of commerce, or communication of secrets. Add, that he was always perfectly frank in imparting what he had learnt, or discover'd, to the public.

His works.

He gives abundance of good things relating to *fossils*, their origin, separation, preparation, purification, and the ways of fitting them for human uses: as also to *vegetables*: but he is chiefly admired as to what relates to *animals*, and the analysis of their parts; in which he follow'd the path trod by *Helmont*, in his book *de Lithiasi*. A noble instance hereof we have in his history of *human blood*; which contains abundance of the most valuable, and exquisite

lue of four thousand pounds, at the marriage of his servant-maid, which were made after this manner: And a piece of a brass warming-pan being cut out by order of queen *Elizabeth*, and sent to em; when abroad, was return'd pure gold. Add, that *Dee* made a present to the landgrave of *Hesse* of twelve *Hungarian* horses; which could never be expected from a man in his circumstances, without some extraordinary means.

In 1591 they went into *Germany*, and settled some time at *Trebona*, in *Bohemia*; the design of which journey is somewhat mysterious. Some say their errand was to visit the alchemists of those countries, in order to get some light into the art of making the powder. Accordingly, they travel'd about those parts, thro' *Poland*, &c. in quest thereof: and some say attain'd it; some not. Others will have them sent by the queen, as spies; and that alchemy was only a pretence, or means to bring them into confidence with the people. So, a book which *Dee* afterwards

published, *Of Spirits*, is conjectured to be, like *Trithemius's*, mere cryptography; which is the light Dr. *Hook* takes it in.

They were no sooner gone, than *Dee's* library was open'd, by the queen's order, and four thousand books, and seven hundred manuscripts taken away, on pretence of his being a conjurer. That princess soon after used means to bring him back again; which, a quarrel with *Kelley* happening to promote, he return'd in 1596; and in 1598 was made warden of *Manchester* college, where he died.

For *Kelley*, the emperor suspecting he had the secret, clap'd him up in prison, in hopes to become sharer with him; but set him at liberty again, and again imprison'd him: from whence endeavouring to make his escape, by the sheets of his bed ty'd together; they happen'd to slip, and let him fall; by which he broke his leg, and soon after lost his life.

things;

things; and on every occasion he endeavours to found his reasonings on experiments. His treatises of the *unforeseen failure of experiments*, and *sceptical chemist*, shew his great modesty, and moderation; and how far he was from that common vice of the chemists, boasting, and promising more than he could perform.

He is author of a vast number of pieces, all composed in the same spirit. They are so many, and printed so separately, that it is exceedingly difficult to procure a complete Collection. His style is a little loose, and diffusive; and the course of his writings sometimes interrupted with digressions, and particularities not very essential *.

One objection is made to him in his chemical character, viz. that taking the virtues of his preparations on the report of other people, he commends some of them too much, and attributes virtues to them which experience does not avow. For, as he did not practise physic himself, his way was, upon making any new preparation, to give it some physicians to make trial thereof; and they, it seems, out of complaisance, would speak more largely of it than it deserved. Hence, those profuse commendations he bestows on the spirit of human blood and hart's-horn in phthical, and on the *Ens Veneris* in rachitical cases.

As to the point of credulity commonly charged on Mr. Boyle; there does not seem to be any great foundation for it: Nobody inquires into things more severely, or speaks of them more dubiously than he. True, a long, and intimate acquaintance with the writings of *Paracelsus*, and *Helmont*, might possibly have some effect on the bent of his mind; and induce him to give too much belief to many of the *arcana* they pretend to: and the more so, considering the great number of strange incidents, and events which had fallen within his own observation.

JO. BOHNIUS, professor at *Leipfic*, deserves to be read again, and again. His *Dissertat. Chemico-Phys.* published in 8°, beside an uncommon reading, shew that he has made a good number of experiments. And as to his reasonings, nobody goes beyond him. His treatise *de Acido & Alkali*, is excellent; and has let a deal of light into the Affair.

HOMBERG is one of the most expert, and masterly chemists of our age. He has distinguished himself by a great number of general experiments, as well as by his reasonings; which are always perfectly fine, and clear, and conducted with all the severity of mathematics. Natural history had received a deal of light at his hands, had his life been continued. He was a person of great genius, profound skill, and indefatigable industry: he was supported by the duke of *Orleans*, late regent of *France*; and perform'd experiments at his expence; which gave him an opportunity of trying many things out of the reach of a private person.

* In the late abridgment of his works, I hoped all these inconveniencies are re- in three volumes in quarto, 'tis to be moved.

His writings are dispersed in the memoirs of the royal academy of sciences, published first by *Du Hamel*, then by *M. Fontanelle*; and in the last edition of *M. Lémery* *.

OTTO TACHENIUS is a good, and experienced author; but too deeply possess'd of the notion of alcali, and acid: to which he reduced, and wrested every thing.

The

* *Monf. Homberg*, the great glory of the royal academy of sciences, was born in the *East-Indies*, at *Batavia*, in the island of *Java*, in the year 1652: his father was a *Saxon* gentleman, who having from his youth been stripp'd of his estate by the conquests of the *Swedes* in *Germany*, went to seek his fortune in *Asia* in the service of the *Dutch East-India* company; where he obtain'd the Command of the arsenal of *Batavia*. Our chemist was his second son, by the widow of a *Dutch* officer, whom he married on the place. The youth was early destin'd for study; but the excessive heats of the climate afforded but little room for application thereto: till upon his father's quitting the service, and the *Indies* at once; and removing with his family to *Amsterdam*.

M. Homberg, now at liberty to follow his natural propensity, was sent to *Jena*, and *Leipsic*, to study law; and in 1674 was admitted advocate at *Magdebourg*. But he soon perceiv'd there was something else in the world to be known, beside the arbitrary laws, and constitutions of men; and the spectacle of nature began to draw his attention, and interest his curiosity. His eyes were first turn'd upon plants: in the day-time he would steal to the mountains, to learn the names, kinds, &c. thereof; and in the night observ'd the stars, and learn'd the names, and dispositions of the several constellations thereof. Thus commencing botanist and astronomer, without knowing what he was about.

At the same time, *Otto Guericke*, famous for the invention of the *air-pump*, the *hemisphere*, &c. was *bourguemaître* of the city. To him *M. Homberg* applies himself to learn experimental philosophy: and that gentleman, tho' otherwise mysterious enough, either reveal'd all his secrets, in favour of his genius, or could not conceal them from his penetration.

His friends seeing him thus estrange himself from the Bar, thought to fix him by marriage; but perceiving the design, he betook himself to travel, and went for *Italy*. At *Padua* he spent a year, in the study of medicine, and particularly of anatomy and plants. At *Boulogne*, he work'd on the stone of that name, and learn'd the secret thereof, which was almost lost. At *Rome* he employ'd himself with *M. A. Celio* in grinding large telescope glasses; not neglecting any of the arts of that country, painting, sculpture, and music. Hence he pass'd into *France*; and thence into *England*, where he work'd some time with the great *Mr. Boyle*, whose laboratory was then one of the best schools of philosophy in *Europe*. From *England* he went to *Holland*, where he perfected himself in anatomy, under the famous *de Graeff*. And after a visit to his relations, now reinstated in *Saxony*, he took the degree of doctor of physic at *Wittenbourg*.

But his pilgrimages were not yet at an end; he was now bent on a visit to the *Virtuosi* of *Germany*, and the *North*; and as by this time he had got a considerable stock of physical curiosities, he began to think of settling a traffic, and getting others in exchange for them. Accordingly, he applied to *Balduinus*; then to *Kunkel*, at *Berlin*, and procured the secrets of their respective *phosphori*. Metals now demanded his attention; and he travel'd thro' *Saxony*, *Bohemia*, *Hungary*, and *Sweden*, to view the mines.

At *Stockholm*, finding a chemical laboratory just established by the king then reigning; he wrought some time therein, with *Hierna*, physician to the prince; and contributed greatly to the first success of the new establishment. Here he was often applied to on occasion of the difficulties which divided the learned; and the journals of *Hambourg*, printed in *High-Dutch*,

The *Philosophical Transactions* of the royal society contain many valuable things in chemistry; chiefly, of those two excellent authors, *Cox* and *Slare*; a great part of which are omitted in *Lowthorp's* abridgment. Those authors write nothing but what they have thoroughly examined; and deserve well to be studied, both on account of their experiments, and their reasonings.

The *History and Memoirs* of the royal academy of sciences are likewise enriched with a great number of the most curious, and exquisite pieces in

are full of memoirs composed by him on such occasions. His next remove was into *Holland*, and from thence into *France*, to pick up what had before escaped him.

From *Paris*, at the earnest solicitations of his father to put an end to his travels and settle among his friends, he was upon the point of returning to *Saxony*; and had even taken coach, with that view, when a messenger came to him from *M. Colbert*, in the king's name. That great minister making him very advantageous offers to settle there; after a little time taken to consider of the matter, he accepted them, renounced his religion, and commenced catholic in 1682; for which he was disinherited by his father.

To avoid being drawn into the vain search of the philosopher's stone, by a chemist, with whom he was employ'd in the laboratory of the *Abbe de Chalucet*; and for some other reasons; he went to *Rome* in 85; where he practised physic with good success: but after a manner little known in that country.

His quality of doctor of *Wittemberg* he made no account of; but practised merely on the foot of a physician by genius. His great sagacity in discovering the causes of diseases and the remedies required, by nice reasoning, served him instead of experience. After a few years he returned to *Paris*; and in 1691, upon the *Abbe de Bignon's* having the direction of the royal academy, he was adopted into the same, and put in possession of the laboratory of the academy. And 'twas chiefly his industry and address in furnishing matter for the meetings, that kept up the company, till its revival in 1699.

The duke of *Orleans*, since regent of the realm, having an inclination to study chemistry, and experimental philosophy:

his preceptor the *Abbe de Bois*, since cardinal, recommended to him *M. Homberg*, as his guide. In 1702, that prince took him into his family, in that quality, allow'd him a considerable salary; and provided him the most magnificent, and best appointed laboratory, chemistry had ever known. Here the princely chemist came daily, receiving the instructions of his tutor with the utmost ardor, and frequently preventing them; entering into all the detail of the operations, performing them himself, and even inventing new ones; so that the master has often stood astonished at his disciple.

The same year, his highness procured *M. de Tschirnhausen's* large burning-glass from *Germany*; a new kind of furnace, of which *M. Homberg* made a noble use. He married a daughter of the famous *M. Dodart*, in 1706: some years after which, he fell into a dysentery; which was cured, and returned again from time to time; till at length, in the year 1715, it put an end to his life.

He never published any express work, or volume in form: His *Essays*, or *Elements of Chemistry*, were begun to be printed in the memoirs of the academy; and the rest of them were found in good order, and fit for the press, at his death. Beside which, there are a great number of lesser pieces, on divers occasional subjects, dispersed throughout the same memoirs: none of which but open new views, and shine with their peculiar light; and there are many of them, which, with the addition of common matters, others would have made whole books of. His way of expressing himself was simple, precise, and methodical; and he was as far from the natural ostentation of the chemists, as from their mysteriousness, and obscurity.

the same kind, by Mess. *Lemery* and *Homburg* above-mentioned; as also Mess. *Geoffroy*, *Lemery* the younger, *Boulduc*, &c.

These authors we would have read in the same order wherein they are here enumerated: and of all the writers in chemistry, tho' almost infinite in number, these few are all we can heartily recommend for the study thereof.



PART

P A R T II.

T H E O R Y O F C H E M I S T R Y.

Chemistry is an Art, whereby sensible bodies contain'd in vessels, (or at least capable of being contained therein and render'd sensible;) are so chang'd, by means of certain instruments, and especially fire, that their several powers, and virtues are thereby discover'd; with a view to the uses of medicine, natural philosophy, and other arts and occasions of life.

This definition may appear prolix, and circumstantial; but with our utmost endeavours, we could not frame a shorter, that would express the full scope, object, and instruments of chemistry, so as to distinguish it from every other art: a thing, all the writers of chemistry have hitherto stumbled at. For chemistry cannot justly be call'd *the art of resolving bodies*, as *Regius*, *Paracelsus* and others define it; since, on such footing, it would not differ from mechanics, which certainly resolves bodies. Nor is the matter mended, by saying it is the *art of analyzing bodies by fire*, as *Helmont* has done; nor *by salt*, as others would have it: These definitions including only a part, instead of the whole. And with as little propriety is it term'd *the art of separating the pure from the impure*; because it compounds as well as separates, and frequently mixes the impure with the pure.

To shew that the definition of chemistry, which we have above delivered, is just, and adequate; we shall take it to pieces, and explain every part thereof: And such explanation will comprehend the whole *Theory of chemistry*.

An Art,

Chemistry, then, is an art; and art is defin'd, by the philosophers, a habit of the mind, operative, or effective, according to right reason; or, more intelligibly, a habit of the mind prescribing rules for the due production of certain effects; or, still more sensibly, the introducing of a change in bodies, from some fore-knowledge or design in a person, call'd an *artist*; in whom resides a principle, or faculty of acting.* To illustrate this by an example: a block of marble being given to a sculptor, whereof to form a statue of *Mercury*, if the man can do the thing, he is an artist; and that principle within him, whereby he is enabled to perform it, is the craft or art; which, apparently is no other than the knowledge he has how to make the statue out of the marble. To this end it is necessary that he have a just idea of *Mercury*, who is describ'd as a handsome, alert youth, with wings, &c. But that is not enough; for every learned man knows this, yet cannot make the statue: he must therefore, know how the thing is to be effected, and by what assistances; particularly, that in any piece of marble all forms are concealed; and therefore, that from the present block he is only to take away every thing redundant, as in the face, hands, &c. but to add nothing. He must know farther, in what manner this retrenchment is to be made; and how much to be taken away: nor is this sufficient; but he must understand by what instruments it is to be done; as the *mallet*, *chissel*, &c. and how to direct these instruments. All which must the chemist know, in his art, as well as the statuary.

Which changes bodies.

We add, in our definition, that chemistry is an art which changes bodies: Whence it appears, that body is the object of chemistry. Now we call *body* whatever is extended, solid, hard, impenetrable, moveable, figurable, ductile, &c. And such body chemistry regards as its object; yet all body has not the privilege of being this object: For bodies we observe are either *sensible* or *insensible*.

And particularly sensible ones.

The *sensible* are such as affect our senses; or have such a determinate magnitude, figure, and distance, with regard to our organs of sense, as to produce changes therein, whose effects come under the notice of the mind.

Insensible are such as do not fall under our senses; that is, such as are either so small, or so remote, that their action on the organ works no notable change. Thus the air, wherewith we are every way surrounded, is full of an infinite number of heterogeneous corpuscles, which have indeed an effect on our bodies; but 'tis such an one as our senses take no cognizance of.

* The less curious of our readers, may not care to enter so far into the metaphysical origin of chemistry. But where so spacious a superstructure is to be raised, one cannot well go too deep for a foundation. Our author's oeconomy here is admirable: His definition is an epitome of his whole book; or the book a paraphrase on the definition. He first gives us the whole in miniature; and then takes every part, in its order, and enlarges it to its proper bulk. When he comes to *body*, that complex thing, the reader would imagine he had lost the view; but, after dilating, and opening it by degrees, till he has discovered all it contains, he returns, and goes thro' the rest. This hint, will let the reader into a method, beautiful beyond expression.

Now,

Now, chemistry only regards *insensible bodies* as its objects, so far as they are *capable of being rendered sensible*; whence, in effect, it considers none but sensible bodies.

It must be added, that even all sensible bodies are not objects of chemistry; but only those which are capable of *being contained in vessels*. Thus the *Moon*, tho' a sensible object, is no object of chemistry, because not capable of being contain'd in vessels. But there are abundance of insensible bodies which may be render'd sensible, and included in vessels; as is evident from chemical spirits; which often are only an insensible aura or exhalation, that would fly away unperceiv'd; but being caught and collected in alembics and retorts, come under the notice of our senses.

The objects therefore of chemistry are of two kinds, *viz.* any *sensible* body fit to be included in vessels; and any *insensible* body capable of being render'd sensible, and included in the like manner.

These objects chemistry considers only so far as they discover themselves by their effects: Thus, what gold is in it self, no body knows; but what it does, we all know; and so far as it produces certain effects, so far we understand its nature, and no further.

In treating of *bodies*, we usually divide all sensible nature into three classes, *viz.* the *fossil*, *vegetable*, and *animal* kingdom. *Body divided into kingdoms or classes.*

This division, which at first sight appears gross and inaccurate, is, in reality, very subtle and adequate; being taken from the three different manners of growth which obtain among bodies. For all bodies either grow adhering to the earth, in such manner, as that there is no apparent distinction of parts containing, and contained, *i. e.* of vessels, and juices circulating in them; which are called *fossils*: Or they grow adhering to the earth, so as that there is a real difference of vessels and juices discernible therein; which are *vegetables*: or lastly, they grow without adhering to the earth at all; and are called *animals*.

Each of them we shall consider in its order, and first

Of

Of FOSSILS, or the Fossil Kingdom.

Fossils.

WE have already divided bodies into three classes; to one or other of which, all of 'em, the primary elements, fire, water, air, and earth excepted, may be referred.

Defined.

We begin with the most simple, and inorganic, viz. *fossils*; the general notion whereof is comprized under the following definition: *A fossil, sometimes also called mineral, is a sensible body generated and growing, in and of the earth, whose consistent parts are so simple and homogeneous, that there is no apparent distinction of vessels and juices; or between the parts and the whole.*

This character holds of fossils, and of them alone: Thus gold, silver, and the other metals, antimony, salts, sulphur, stones and other minerals, really grow *fixed to the earth*; and in such manner, that if they be divided into the minuteest parts, they will every where appear the same similar solid matter, without any shew of *vessels and humours*. And thus, should it be urged that spirit of wine must, on this footing, be a fossil, because homogeneous in all its parts, and exhibiting no distinction of vessels and juices; the answer is obvious: since spirit of wine, as such, is not generated of or under the earth; neither is it a *vegetable*; that denomination including the whole compages or structure, out of which the spirit of wine is prepared. Or, if a second should argue, that *antimony* should then be no fossil, since it contains a sort of heterogeneous sulphur: 'tis answered, that as to our senses, 'tis in all respects a fossil; since whatever portion you take thereof, 'tis the same indistinguishable matter, and has all the characters of *antimony*.

Fossils divided.

Now *fossils* are either simple or compound: *Simple* are such whose parts, howsoever divided, are all of the same nature, i. e. of the same gravity, magnitude, figure, hardness and mobility: As quick-silver, which tho' divided to infinity, is found every where the same in all these respects.

Compound are those which may be divided into different, or dissimilar parts; or, whose parts are unlike in magnitude, figure, hardness and mobility: As antimony, which may be resolved by fire, into sulphur, and a metalline part.

Simple fossils.

The SIMPLE FOSSILS are, 1. *metals*, 2. *salts*, 3. *stones*, both vulgar and precious; and 4. *earths*.

Compound fossils.

The COMPOUND FOSSILS are, 1. all *sulphurs*, 2. *semi-metals*, or what we properly call *minerals*, 3. bodies combined out of the preceding fossils, either simple or compound.

Metals making the primary head in fossils, we shall treat of 'em in the first place.

First Class of Fossils.

METALS.

A Metal is a simple, fossil body that fuses, and becomes fluid by fire, and ^{Metals defined.} by cold coagulates and hardens into a solid mass, capable of distending under the hammer.

We call it *simple*, since it may be said of every the minutest particle of a metal, e. gr. a grain of gold, that *it is gold*, or has all the properties of gold. *Fusible by fire*, that is, when exposed to a great fire, it dissolves into parts which are easily moveable among themselves, or perhaps are in actual motion. *Fixed*, i.e. bearing the fire without flying off in vapour: tho' 'tis only to a certain degree that metals are fixed; for by the large burning glasses of Mess. Tschirnhausen and Villette all metals readily evaporate.

Such is the proper idea of a *metal*, which is no ways applicable to any other body in nature: for a diamond, tho' a simple body, is not *fusible* in the fire, nor capable of being *stretched under the hammer*. And salt, tho' dissolvable by fire, is not *malleable*, but breaks under the hammer. It may be added, that there are certain woods which yield in some measure to the hammer; but then they fall to dust in the fire: and so of the rest.

We find but six METALS in all nature, viz. *gold, lead, silver, copper, iron, Divided.* and *tin*: tho' to these the chemists usually add a seventh, viz. *mercury* or *quick-silver*; but with some impropriety, as it has not all the characters of a *metal*, nor scarce any thing in common with the other metals, except weight and similarity of parts. Thus it is neither dissoluble by fire, malleable, nor fixed; and in effect, it seems to constitute a peculiar species or class of fossils. But the chemists, tho' at first they seem to have been overseen, yet have somewhat to alledge in their behalf: for mercury, they hold the basis or next matter of all metals; or, if you had rather, metals themselves are only mercury fixed: and thus by only throwing in sulphur, its parts are bound together, and form a metal. Hence, as 'tis only a circumstance that is wanting to make quick-silver a metal; so near an affinity may well warrant the calling it by that Name.

These metals, have obtain'd a kind of *apotheosis*, or translation into heavenly bodies, or planets: thus gold is called *sol* or the *sun*; silver *luna* or the *moon*, &c. which proceeded, no doubt, from some similitude, which the ancients imagined between the planets and the metals.* The planets we know took their names from hero's and deities; and the same names came in time to be given to metals.

* Thus, in the table of emeralds ascribed to Hermes, 'tis frequently repeated that the metals below are the same as those above. And we read of an ancient Coptic Inscription near the city Memphis in these terms; There is heaven above, and heaven below; stars above and stars below: every thing that is above is below.

The ground
thereof.

Nor does the thing appear preposterous, if closely attended to : for that vigorous brightness is not less conspicuous in *gold* than in the *sun* : the white colour of *silver* agrees very well with that of the *moon* : the glittering fierceness of *Mars*, bears a near resemblance to that of red-hot *iron* : the pale livid aspect of *Saturn* is well represented by the colour of *lead* : and the variety observed in the appearances of *Venus*, is imitated by the different colours of *copper* ; and so of the rest.

The *caballists*, and after them the astronomers, use the same characters to denote the planets, as the chemists do for the metals ; and hence the scale of the seven planets in heaven, and of the metals on earth, is the same.

The characters
they are denoted
by.

The characters which denote the metals, and some other chymical subjects, are these.

☉ Gold	} or {	Sol,
☽ Silver		Luna.
♀ Copper,		Venus.
♂ Iron,		Mars.
♄ Tin,		Jupiter.
♅ Lead,		Saturn.
☿ Quick-silver,		Mercury.
+ Vinegar		Corrosiveness.
♁ Antimony,	}	The king's bath.

These characters appear to have been in use among the most ancient chemists. They are said to be of a thousand years standing ; and to have been originally taken from the religion of the *Persians*.

'Tis certain, there have always been two ways of writing : the one by *letters*, arbitrarily pitch'd on to denote things ; as that in use among us : the other by *characters*, or images of the things denoted, called *hieroglyphicks* : such was that of the ancient *Egyptians* ; who to denote a dog, put a dog's-head ; for a stout man, a lion ; for a perfect thing, a circle, &c. which manner still obtains among the *Chinese*, and hence that difficulty, so much complain'd of, in learning their language ; the number of their characters being so great, that even the most learn'd among their *Mandarins* scarce understand a twentieth part of 'em. The images they use are such as we sometimes see in our porcellane, or china-ware, which those people readily read.

Rationale of the
characters.

This hieroglyphic or caballistic manner of writing was adopted by the chemists ; who denoted their metals by characters that seem drawn from the very depths of chemistry, and hold forth the intimate nature of the metals themselves. Their first character

☉ *Gold* is a circle, with a point in its centre : now the circle, 'tis notorious, is a symbol of perfection, and simplicity ; and was always used as such by the ancient caballists : in reality there is no figure more simple, uniform, or perfect than this ; it comprehends the greatest space under the least superficies ; and all the *radii* drawn from its centre to its circumference are equal ; properties which correspond very aptly to the sun in the heavens, and to gold on the earth.

For

For gold is the most simple of all metals; every particle thereof being of the same nature with the whole: and at the same time it is the most perfect; as being the heaviest, and including the greatest quantity of matter under the least surface. Its nature therefore is well denoted by the figure above described.

☉ Is the character signifying *silver* on earth, and the *moon* in the heavens. This figure would be a perfect circle, if the inner part were properly applied to the outer: thus of ☉, CC, would arise O.

Now, the chemists all agree, that silver is half-gold; or, that part of it is gold; only, that part lies hid. Accordingly, its character denotes gold half perfected; for, say they, if you can but turn the gold-part that lies hid in the silver, outwards; your silver will be converted into gold. Thus gold being accounted the most perfect of all metals, silver comes the nearest thereto; consequently 'tis a sort of semi-gold. *Monf. Homberg* shews, that pure silver, perfectly purg'd of all gold, being kept a long time in the fire, always gains a little portion of gold, *i. e.* part of it becomes gold.

☿ *Copper*, is a circle, with a cross underneath; and denotes that the body or basis is gold, tho' join'd with some corrosive menstruum.

For a cross, + is the character whereby all corrosives, as fire, *aqua fortis*, vinegar, and other sharp dissolvents, were denoted by the ancients; those being things that use to torment, and as it were *crucify*: now, all the adepts allow copper a noble metal, only debased by a sharp, corrosive, or arsenical poison adhering thereto, which is capable of destroying men; and which taken away, the copper is left gold. Accordingly copper, of all metals, silver only excepted, is allowed to come nearest gold.

♂ *Iron*, this character likewise denotes gold at the bottom; only its upper part too sharp, volatile, and half corrosive; which being taken away, the iron would become gold.

Accordingly, the chemists hold that iron comes nearest to gold after copper. 'Tis *Basil Valentine's* tenet, that *Mars* and *Venus* together make *Sol*. The same author introduces iron by way of *prosopopœia*, saying, if you put off my eloaths, *i. e.* the corrosive, you will come at my soul, *i. e.* the intrinsic nature of iron.

♂ Tin is held to be one half *luna*, or silver, and the other half corrosive; which is denoted by the semi-circle, and the cross added thereto. ☉+ In effect, it comes the nearest of all metals to silver, and has most of the properties of it, excepting weight: and they agree in this particular circumstance, that they both grow bitter in acids; which no other metals do. *Mr. Boyle* is even of opinion, that tin and silver are the same body; only that there is a deal of corrosive sulphur in the former: hence silver and tin fused together, mix and cohere so intimately, that there is scarce any separating 'em, even by lead.

♂ *Lead* appears to be the character of tin inverted, with the corrosive passing through the middle. It is variously wrote; has frequently a double cross ☿, to shew that it corrodes on all sides.

Accordingly, all metals are destroyed by lead; gold and silver only excepted: and hence this character is here used to denote it principally as a

corrosive, tho' the middle part bears some resemblance to *luna*, or silver; as there is a real correspondence in colour, taste, &c. between lead and silver.

¶ *Quicksilver* evidently shews gold in the middle, or body of it, silver at top, or in the face, and a corrosive at bottom: accordingly all the *adepts* say of mercury, that it is gold at heart, whence its heaviness; that its outside is silver, whence its white colour: but that there is a pernicious, corrosive sulphur adhering to it, denoted by the cross; that if its brightness, and its corrosive could be taken away, it would remain gold; that the quantity of sulphur is here so great, as to render it wholly combustible by fire; that the more 'tis burnt, the nearer it comes to gold; and that were it perfectly calcined and purified, and its colour changed, it would be gold.

The like is asserted by *M. Homberg*; viz. take out the corrosive sulphur denoted by +, and the whiteness signified by σ , and mercury, will be $\odot$ gold. And hence that maxim upon mercury: Strip me of my clothes, and turn me inside out, and all the secrets of the world will come forth.

§ *Antimony*, is a circle, denoting the body of gold; to which a cross is added, to shew it a corrosive; and because the corrosive prevails, the cross is placed at top. Accordingly antimony is the destruction of all metals, except gold; the other five, with stones, salts, &c. being all lost in the corrosive.

Again, the character of antimony is the same with that of *tellus*, or the earth; as being a sort of chaos or universal body; and accordingly *Basil Valentine* calls it *omne in omnibus*.

We now see why the ancient chemists had recourse to a kind of images of bodies, and directed their followers to seek for all things, in the grand world; as is well shewn by *Pantaleon* and *Suchten*. The truth is, something obtains in the planets and heavenly bodies, very like what we see in minerals; so that there is a real foundation for the allusion.

Distinguishing
character of
metals.

The common radical character of metals is, that of all known bodies they are the heaviest: by *Dr. Halley's* experiments, the weight of gold to that of glass is determined to be as 7 to 1; and the weight of tin, tho' the lightest of all metals, to that of gold as 7 to 19; which considerably surpasses the weight of all stones, marbles, gems, and other the most solid bodies; as appears from the tables of specific gravities.

Their weight.

The lightest of all metals, therefore, is six times as heavy as water; and there is no body, beside a metal, whose weight will hold that excess. So that to the definition of a *metal* above laid down, we might add this circumstance, that it is at least six times heavier than water.

This being laid down, it appears from the ancient atomical philosophy, so nobly retriev'd by *Sir Is. Newton*, that the matter of bodies is proportionable to their weight; or that the weight of any body is as its substance. Now, this holds peculiarly of metals, which are so perfectly distinguish'd from other bodies by their weight, that no body but a metal can have the weight of a metal.

The

The royal society furnish us with various experiments in this kind: the weight of the several metals and other solids, they have examin'd hydrostatically, by weighing 'em bulk against bulk, in air and in water; and the weights of the fluids, by weighing an equal portion of each. By such experiments they find, that taking the same weights of water and gold, the bulk or magnitude of the former is to the latter as 19636 to 1000: consequently, that the weight of gold is to water nearly as 19 to 1.

The specific weights of the several metals thus determined, stand as follows.

Gold————	19636	Iron————	7852
Quicksilver—	14019	Tin ————	7321
Lead————	11345	Stone———	2000
Silver————	10535	Water ———	1000
Copper————	8843	Air————	1 $\frac{1}{7}$

But it is to be observ'd that such weights cannot be ascertain'd to geometrical exactness, unless we know the just proportion of the heat and expansion of the metals; for the same degree of heat will rarify one metal considerably more than another. Add, that there will some inaccuracy arise from the air; its weight to that of gold, is here laid down as 1 to 19; but this is only to be understood of pure fine air, such as that about *London* or *Paris*: grosser air, as that in most parts of *Holland*, is found to gold as 1000 to 1. If what Mr. *Boyle*, and M. *Mariotte* contend for, be true, viz. that air is capable of being condensed *ad infinitum*, it may even be made heavier than gold; as by being compress'd above 19 thousand times, it must be: but this is chiefly conjecture.

This doctrine of specific gravity of metals is of the utmost use in the business of mines: for if in digging, you meet a glebe or mineral, whose weight is 6 times as great as that of water; you may safely conclude there is metal therein. Again, if the gravity of the body found be to that of water as 18 to 1, you may rest secure there are at least, $\frac{1}{4}$ parts of gold in it: for as there is no body heavier than gold, nor any body that comes nearer the weight of gold than pure quick-silver, whose weight is to that of water as 14000 to 1000, or as 14 to 1; it follows of necessity, that the body, whose weight is as 18 to one, must have $\frac{1}{4}$ parts of gold in it. And if the other parts be not quick-silver, but some other body, the proportion of gold therein will be still greater.*

Knowledge there-
of necessary in
digging mines.

Gold,

* The origin and formation of metals is somewhat obscure; tho' we have two or three systems to account for it: the first supposes the metalline particles to have been form'd from the beginning, and ranged by the law of gravity, in regular strata, next the center of the earth; from whence they have since been raised by the action of the central heat, up toward the surface, and deposited there in all parts of the globe. Such is the opinion likewise of many of the modern naturalists, as of *Des Cartes*, *Dr. Woodward*, &c. The second sets aside this pre-existence, and supposes metals to be form'd

Gold, then, being the heaviest and noblest of all metals, we begin with gold, and proceed to the rest in the order, wherein their gravity places them.

GOLD.

form'd, or generated *de novo*, by the occasional mixture of certain matters, wherein nothing of a metalline nature was before contained.

This opinion, which is the most ancient, and withal the most common, is confirmed from the instance of artificial metals. M. Geoffroy, from a mixture of sulphur, a vitriolic salt, and a clayey earth, brought an iron, which he maintains to be a new production, or a composition of those principles. He adds, that the ashes of all vegetables afford iron, which it would be hard to suppose lodg'd in the plant it self, and must rather be deem'd the effect of the fire in calcination. Again, clay does not shew the least sign of any metal, work it how you will, without mixing; but add linseed oil to it, and by fire you will have a metal, which is no other than real iron. In effect there are divers other matters, which give no suspicions of being metalline, and yet afford a ponderous substance, to which fire gives all the properties of iron; so that 'tis probable, metals are only form'd by the assemblage or combination of certain matters or principles; much as sulphur is, by the admixture of an inflammable principle, with a vitriolic salt. When these matters, which we may suppose continually circulating thro' the pores of the earth, meet with an earth which has an affinity with 'em; they stick therein; and thus arise *mines, metalline veins, &c.*

What farther confirms this, is, that if earths or stones of different kinds be put in a mine, different metals will be produced therein. Thus *Albertus Magnus* remarks, that the same stamen of gold by adhering in different glebes has degenerated into silver: and several other authors affirm, that by changing the earth of a mine, the metal becomes changed.

M. Lemery, the younger, attacks this system with great address: the iron in the ashes of plants, he maintains, really exist in the plants themselves; being rais'd in their vessels, along with the juices of the

earth: and for M. Geoffroy's artificial iron, he avers, that its ingredients do all really contain iron in themselves; and mentions the operations whereby it may be extracted.

To this M. Geoffroy answers, that the quantity of iron procured from each of the ingredients, separately, is infinitely less, than when they are mixed; so that the mixture still produces metal. Beside, M. Lemery uses oil in the operations; now oil is not a simple substance, but is compos'd of earth, an acid, and a sulphurous part, which are the very three principles required to the formation of iron: so that in all probability, the fire, by more closely assembling, and uniting these principles, makes the iron it was thought to extract; the means used to procure the supposed iron from the ingredients being precisely the same with those whereby iron is compos'd. And thus does the noble strife stand, as it were in *equilibrio*; to be determin'd as new lights, and future discoveries, shall direct the scale.

In the mean time we may add, that iron is not only producible, by the mixture of different substances, wherein there was no appearance of iron before; but even in the same, simple substance, by mere force of fire: thus Mr. Boyle relates, that he had a ruddy, mineral powder, which the load-stone had not the least effect upon; but which being wetted with linseed oil, and then kept glowing hot in a crucible for two hours, turn'd blackish, and would then adhere to the same load-stone, almost as readily as if it had been a heap of iron filings. But, continues he, the operation of the fire, perhaps, contributed to the change as much as the linseed oil; for some of the same red powder being kept ignited in a crucible, without the liquor, afterwards appear'd magnetical. *Mech. Prod. of Magnet.*

The third opinion is that of M. Tournesfort, who holds that metals have their origin from seeds or eggs; that their production and growth is no more than an opening, or expansion of the seminal parts; and in a word,

G O L D.

THE first property, or characteristic of gold, is, that it is the heaviest Gold of all bodies in nature. We have observ'd, that it weighs nineteen times more than water, taking bulk for bulk: and this property is inseparable from it; no assured method having ever yet been found out to render gold more or less heavy *. Add, that whereas all the other properties of gold may be imitated, its weight alone is inimitable. Where-
 ever therefore we find the specific gravity of gold, *i. e.* nineteen times the weight of water; there, beyond all contradiction, is real gold: So, if I have a mass of matter heavier than mercury, it is sure that there is a share of gold in it; there being, as already observed, no intermediate body between mercury, and gold; *e. gr.* no body, which is, to gold as 16, or 18, to 19.

word, that they are organized bodies, and have vessels with juices circulating therein.

This Theory, which is chiefly founded on a supposed analogy between the several works of nature some authors are fond of, we shall have occasion to speak of more fully hereafter.

Metals are chiefly found in mountains; but whether it be that they grow more there than in plains, or only are easier come at, and more commodiously dug, does not appear. The signs by which they discover a Mine, are, the mineral taste of the water; the exhalations it emits; the difference between the face of the soil there, and in the adjacent parts, in frosty weather; and lastly, bareness of grass, and the pale hue thereof.

Mines are sometimes open'd e'er the metals be quite form'd; and are shut up again, to give time for their coming to maturity. Others, after they have been quite exhausted, and have lain by for several years, are found as rich again as ever: instances of this Mr. Boyle gives us in tin mines; *Agri-cola*, *Boccacius*, &c. in lead mines; *Pliny*, *Strabo*, and *Casparinus* in iron mines: the like accounts Mr. Boyle mentions of silver mines; but he could hear of none of gold mines. It is likewise found, that the ore of lead, and other metals being wrought, and laid

by in heaps, does, in tract of time, become impregnated anew. Add, that at the famous gold mine at *Cremnitz* in *Hungary*, after a vein is almost spent, they cast in large quantities of earth; which after some years affords gold as before: and at *Corbac* in *Westphalia*, they melt gold out of their heaps once in four years, in which time it is generated afresh.

The veins of metals always follow one constant direction: if they run southwards, they never decline either to the east, or west: and if they happen to be interrupted, as by rivers, &c. they resume their former direction on the other side. Indeed there are some, very rare, instances of a vein's taking a new direction: but then it persists inviolably therein. *Nouv. Cours de Chymie.*

* My Lord Bacon, indeed affirms, that he had the secret of making mercury penetrate gold, so as to increase its weight very considerably, without any addition to its bulk. Whether or no his process will answer, we cannot say: the experiment is too costly to make. But there is nothing improbable in the thing. For gold, for all its great weight, is known to be very porous: water may even be forc'd thro' its interstices, and why not mercury? Sir I. Newton computes, that gold has even more pores than solid parts. *Optic. p. 242.*

Whoever

Whoever, therefore, would make gold, must be able to add to the weight of other metals; so as to render them equiponderant with gold.

To prove its truth.

Hence, if any fraudulent alchemist should obtrude a metal on you for gold; take a piece of pure gold, hang it by a hair or thread to a nice balance, and hang an equal weight of the suspended gold by another hair, to the other end of the beam; then immersing both pieces in water, if the alchemist's gold be pure, the water will retain both pieces *in equilibrio*, as before; otherwise, the adulterate metal will rise, and the pure descend.

Its ductility, and malleability.

The *second property* of gold is, that of all known bodies, it is the most ductile, and malleable; and, of all bodies, its parts cohere with the greatest obstinacy*.

Our gold-beaters, and wire-drawers, furnish us with abundant proofs of this property: they every day reduce gold into leaves or *lamellæ* inconceivably thin; yet without the least aperture, or pore discoverable even by the microscope: a single grain of gold may be stretched under the hammer into a leaf that will cover this house; and yet the leaf remain so compact, as not to transmit the least ray of light; nor even admit spirit of wine, the finest and subtlest fluid in nature, to transude, or pass thro' it.

Dr. Halley took the following method to compute the *ductility* of gold: He learnt from the wire-drawers, that an ounce of gold is sufficient to gild, *i. e.* to cover, or coat, a silver cylinder of forty-eight ounces weight; which cylinder may be drawn out into a wire so very fine, that two yards thereof shall only weigh one grain; and consequently ninety-eight yards of the same wire only forty-nine grains. So that a single grain of gold here gilds ninety-eight yards; and of course the ten thousandth part of a grain is here above one third of an inch long.

And since the third part of an inch is yet capable of being divided into ten lesser parts, visible to the naked eye; it is evident that the hundred thousandth part of a grain of gold may be seen without the assistance of a microscope.

Proceeding in his *Calculus*, he found, at length, that a cube of gold, whose side is the hundredth part of an inch, contains 2,433,000,000 visible parts: and yet, tho' the gold wherewith such wire is coated, be stretch'd to such a degree, so intimately do its parts cohere, that there is not any appearance of the colour of the silver underneath †.

This

* Sir I. Newton, shews, that the primitive, or component particles of all bodies, are hard: that they are only laid together; and that the cause of their cohesion is some attractive force superadded to 'em, whereby they unite together into larger particles, and those, at length, into sensible masses. Now, if the composition be so, as that the particles, under the circumstances of their

attractive or cohesive force, are liable to slide easily on one another, the body becomes ductile, or malleable, or soft. *Newt. Optics. p. 370.*

† Mr. Boyle examining some leaf-gold, found, that a grain and a quarter's weight took up an area of fifty square inches: supposing, therefore, the leaf divided by parallel lines $\frac{1}{16}$ of an inch apart; a grain of

This tenacity, or force of cohesion in the parts of gold, which appears scarce less than infinite, depends altogether on its being freed from sulphur: for mix but one single grain of sulphur with a thousand grains of gold, and the mass ceases to be malleable, till all the sulphur have been evaporated. And hence we have a strong presumption, that the less tenacious metals, tin, copper, and iron, contain a great deal of sulphur. Depends on its being free of sulphur.

The immense divisibility of gold is learnt from another experiment: for example, take a pound of silver, and fuse it with a single grain of gold; the gold will diffuse itself equally through every minute particle of the silver; so that taking a grain of the mass, and dissolving it in *aqua fortis*, you will find a quantity of gold fall to the bottom, which has precisely the same ratio to the grain of gold, as the gold in the mass had to the whole mass.

The third character of gold is to be the most fixed of all bodies, i. e. to its fixedness. It loses least in the fire.

Natural bodies are reducible to two classes, *fixed* and *volatile*: the first, such as bear the utmost violence of the fire, without evaporating, or losing any thing of their weight: the second, such as fly away in fume. Now, of all metals, gold and silver alone are accounted fixed; but gold much more so than silver.

Gasto Claveus, the Prince of *Mirandula*, and others, have made experiments to this effect: A quantity of very pure gold being placed in the eye of a glass-furnace, wherein was a very great flame, and of consequence a

of gold will be divided into five hundred thousand minute squares, all discernable by a good eye. For gold-wire, the same author shews, that an ounce of gold drawn out therein, would reach 155 miles and an half. *Nat. of Efflu.*

But *M. Reaumur* has carried the ductility of gold to a still greater length: A gold-wire, every body knows, is only a silver one gilt. This cylinder of silver, cover'd with leaf-gold, they draw thro' the hole of an iron; and the gilding still keeps pace with the wire, stretch it to what length they can. Now, *M. Reaumur* shews, that in the common way of drawing gold-wire, a cylinder of silver 22 inches long, and 15 lines in diameter, is stretch'd to 1163520 feet; or is 634692 times longer than before; which amounts to about 97 leagues. To wind this thread on silk, for use, they first flatten it; in doing which, it stretches at least $\frac{1}{2}$ further; so that the 22 inches are now 111 leagues: but in the flattening instead of $\frac{1}{2}$, they could stretch it $\frac{1}{3}$; which would bring it to 120 leagues. This appears a prodigious extension; and yet it is nothing.

The cylinder of silver might only have been cover'd with one ounce of gold, instead of six which we have hitherto supposed: the gilding, indeed, in this latter case, will be but thin; but still 'twill be gilding, and no point but will have its cover of gold. On this footing, *M. Reaumur* computes, that the thickness of the gold-leaf on the wire, is $\frac{1}{540000}$ of a line. He adds, that as the gold-leaf is not every where of the same thickness, but at least twice as thick in some parts as others; in the thinnest parts it will not be above a 525000th part of a line, or the 6300000th part of an inch.

Yet is not this the furthest we can go: In flattening the wire gently between two wheels, it may be extended to double the breadth hitherto supposed; in which case the thickness of the leaf will be reduced to less than a millionth part of a line, or a twelve-millionth of an inch.

Yet, after all, putting a piece of this gilt wire in *aqua fortis*, the silver will be dissolved, and the gold left a perfect, continuous tube. *Mem. de l'Acad. An. 1713.*

very

very intense heat; it was found at the end of two months not to have lost any sensible part of its weight; tho' it had been all along kept in a continual fluor, insomuch that all other bodies would have been entirely dissipated therein in a much less time*.

Cause thereof.

Whence this property should arise, is not easy to say; unless it be hence, that the particles of gold being all homogeneous, and equal, do equally sustain each other, and leave equal pores between them, through which, when fused, the fire finds an easy passage. The same property is observable, tho' not in the same degree, in silver: the other metals are much less fixed, as containing too much sulphur, which volatilizes, and carries them off in fume.

From this circumstance of fixity, some have argued, that gold alone has its just proportion of fire; and is itself no other than fire perfectly concentrated†.

But M. Tschirnhausen, and others, have made large double burning-glasses, in whose *Foci* even gold itself readily volatilizes, and evaporates||: particularly, in the year 1709, a quantity of gold was thereby converted into glass**; being first fused into a sort of calx, which emitted fumes, and lost of its weight: tho' the same calx, fused again with a portion of fat, was restored to gold. And the like experiments have been made at London with M. Villette's burning concave.

Hence

* It may be observed, however, that gold, mix'd with other volatile bodies, does evaporate; but this is the effect of the great volatility of those bodies, which can carry off the gold along with them. "If we consider," says Mr. Boyle, "how very minute the parts are whereof gold consists, and into which it is divisible, it will not seem impossible, that if we could light of volatile salts of figures fit to stick fast to the corpuscles of gold, they would carry them up along with them. Accordingly, we have made more than one menstruum, with which some particles of gold may be carried up: but upon applying the *menstruum peracutum*, which consists of spirit of nitre drawn from butter of antimony, I was able, without a very violent fire, and in the space of a few hours, to raise so much crude gold as afforded a considerable quantity of sublimate." *Mech. Orig. of Volatil. &c.*

† M. Homberg, and others, we have already observed, make gold consist of mercury, and sulphur; and the sulphur, to be nothing but the matter of light, or

fire. See the note p. 16. As also the chapter, *Of Fire*.

|| Gold exposed, in a cuppel, to a large burning-glass, crackles, emits fumes, gradually diminishes, and leaves a ruddy dye around the vessel: 'tis, probably, no other than the earth of the metal that gives that redness; for there is no recovering of any thing like gold from it: so that one would imagine it something accruing from a sort of analysis of the gold.

** Some philosophers, however, contest the reality of this vitrification: 'tis certain, that if gold be exposed to the focus of a burning-glass on a piece of charcoal, as is usually done, it sensibly diminishes; and in proportion to the diminution, there arise an infinite number of little glassy drops of a greenish colour, which swell, and enlarge, in proportion as the gold disappears. "But this," say some, "is no demonstration that the gold is vitrified: 'tis rather the ashes of the coal, which, amalgamating with the gold, afterwards vitrifies: for let gold evaporate on a body which yields no ashes, and you have no glass. Add, that if this glass be fused over

Hence, we conclude, that there is no body absolutely *fix'd*, in all nature; since gold, which has the fairest pretensions, is not so.

The fourth *character* of gold, is that it requires a vehement fire, to fuse *fusibility*. it; greater, considerably, than either lead, or tin; tho' a much less than iron, or copper *††*.

Add, that whereas some metals, as tin for example, dissolve e'er they ignite; gold ignites, or grows red-hot, e'er it dissolves: which difference arises hence, that the one sustains a greater degree of heat, e'er it fuses, than the other.

Its *fifth character* is, not to be dissolvable by any menstruum in nature, *In what men-* except *Aqua regia*, and mercury. *struums dis-*

Aqua regia takes its denomination from this property of dissolving gold, *Aqua Regia.* which among the chemists is called *Rex*, the king; its basis, or essential ingredient, is common, or sea-salt, which answers the purpose in whatever form applied; whether as a fluid, or a solid; a liquor, or a spirit.

Sal-gem, and sal-armoniac, do either of them occasionally answer the same end, as sea-salt; but 'tis only so far as they are of the same nature and kind with sea-salt; as will be shewn in the chapter, *Of Salts*.

Aqua regia, then, is a sort of *Aqua fortis*, or acid spirit, wherein there is a small proportion of sea-salt: 'tis prepared four several ways:

1°, By mixing common salt, sal-gem, or sal-armoniac, whether native *Preparation of* or factitious, with *Aqua fortis*, or spirit of nitre. *Aqua Regia.*

2°, Of butter of antimony, with which Mr. Boyle made a menstruum that dissolved gold with surprizing readiness; but this does not infer, that gold may be dissolved without sea-salt; for butter of antimony is made partly of mercury sublimate, wherein sea-salt is one ingredient*.

3°, *Aqua regia* may be made of sea-salt reduced into a *spirit*, by distillation; for such spirit of salt is known to dissolve gold.

4°, Of human urine; for this being distill'd by a vehement fire to make *phosphorus*, there remains at the bottom of the vessel a sort of a salt perfectly like sea-salt; which, mixed with spirit of nitre, makes a menstruum that dissolves gold.

To conclude, no spirit, or salt, whether acid, or alcalious, affects gold, unless it have a mixture of common, or sea-salt: thus, if you take a dram of gold, put it into a clean glass-vessel, and pour upon it spirit of sulphur *per campanam*, oil of vitriol, or spirit of nitre, either hot or cold; it will

" over again, and a fatty matter added
" thereto, it does not return to its former state of gold, as all other metals are
" found to do. *Nouv. Cours de Chymie*, p. 272.

†† M. Flacourt, indeed, in his history of the island of *Madagascar*, mentions a kind of gold found there, called by the natives, *Malaccassan* gold; which melts almost as easily as lead: while the fine gold we

deal with, requires vehement fires, with borax to facilitate its fusion. Boyle *Useful of Exper. Philos.*

* *Jos. Agricola* tells us, what seems very strange, that the spirit of *Terra Silesiaca* dissolves gold, as well as *Aqua Regia*, tho' more slowly, into a red solution, which in a few days precipitates the gold in fine powder. Boyle *Useful of Exper. Philos.*

K

have

have no effect on the gold; or if *Aqua fortis* be distil'd from nitre and vitriol, the gold will remain as untouch'd as if it were a diamond: but if into so many vials, each containing one of these saline liquors, with a quantity of gold, you pour a little sea-salt, or sal-gem, either in form of a spirit, or of a lixivium; the gold will be instantly dissolved; and soonest in the vial that contains spirit of nitre. 'Twas a notable saying, therefore, of the antient chemists, that the *Sun and Salt contain all things*. The truth is, sea-salt is a thing of so very beneficial a nature, that we had better be without gold, than this salt.

Gold attracts
and absorbs
mercury.

The sixth character of gold is, that it readily, and spontaneously, as if by some magnetic power, attracts, and absorbs mercury.

Its specific gra-
vity diminish'd
absorby.

Tho', what my Lord Bacon writes, viz. that gold imbibing mercury, increases in weight, we doubt is not well warranted. See his *Nat. Hist.* pag. 124. *Edit. Francofurt.* In effect, we have made the experiment with contrary success; having always found the gold dilated, or increased by the mercury in bulk more than weight; and consequently its specific gravity diminished. Thus, if a grain of mercury be mixed with two grains of gold of 20-carats fine, and the mass be weigh'd hydrostatically against two grains of the same gold, void of mercury; it will be found specifically lighter: Add, that as soon as the mercury enters the gold, it is render'd soft, and like a paste; and of consequence is thinn'd or diluted. Upon the whole 'tis probable, that the noble Bacon had not himself made the experiment, but took the relation from others.

The seventh character of gold is, that it resists the force both of lead, and antimony: by *resisting*, we mean, that when melted with them in the cupel, it does not dissipate, and fly off with them in fume; but remains fixed.

The chemists have two kinds of lead, or *Saturn*: viz. the *Saturn* of Diana, or common lead; and that of *Sol*, called also the *Saturn* of the philosophers, which is antimony. None but gold and silver resist the first; and none but gold alone the second; each they term *Lavacrum Leproforum*, or the *Lepers Bath*; from which they arise the cleaner; intimating hereby, that all other metals by them deem'd leprous, ☉ and ☾ excepted, fused in the same cupel with lead, or antimony, fly off in fume.

Lead, particularly, they call *Balneum Solis & Luna*, *The Sun and Moon's Bath*; or, *Balneum Regis & Regina*; as silver and gold thence come out the purer, and all other metals perish therein.

Sustains the
force of lead.

Thus, if a mass, consisting of gold, silver, copper, and other metals, together with stones, and other bodies, be fused with ten times the quantity of lead; the stones, and all the other bodies beside metals, will swim on the surface, and be easily blown off by the bellows. In the mean time, the lead drawing all the metals, except the gold and silver, to itself, rises along with them into a sort of froth; and is likewise blown off by the bellows, or goes away in fume, or vitrifies with the cupel.

As to antimony, a quantity thereof being put in a cupel, along with pure gold, and the whole fused, and kept in a strong fire; the antimony all evaporates, and leaves the gold alone: which does not hold of any other metal, not even silver itself. Whence antimony is particularly called *Balneum Solis*, the sun's bath; and *Lavamen solius Regis*; *Devorator*; and *Lupus Metallorum*, &c.

Centivoglio introduces antimony, saying, by way of prosopopœia, "I have a bath wherein every thing that enters is lost, except the king, who washes therein with security, and comes out the fairer, only he loses his cloak:" where, by *cloak*, is meant the pellicle usually found on the surface of the gold; or else the heterogeneous matters mix'd with it. For a mass of metals, stones, and earth, being fused with antimony, all but the metallic part will be thrown off together with the impurities of the metal.

Hence, antimony is used as the last test of gold; to try the purity whereof, one or two grains is melted in a cupel with twenty-times the quantity of *regulus* of antimony, till such time as the antimony is either evaporated, or turn'd to a scoria, to be blown away by the bellows, and the gold have *fulminated*, as the refiners affect to call it; that is, till its surface appear every where similar, and equable. This done, if the gold have lost nothing of its weight, it is allowed perfectly pure, and called gold of twenty-four carats; or if it be found $\frac{1}{4}$ lighter, it is said to be twenty-three carats fine.

The eighth character is, that its sound, when pure, is not very clear, or tinkling, but rather obduse, and resembling that of lead. Its sound.

For gold being soft and flexible, has but little elasticity, and consequently is not much disposed to the trembling or vibratory motion necessary to produce sound. Add silver or copper to it, and it becomes sonorous enough: but without any admixture, the chemists even hold, that it yields no sound at all.

Hence, the chemists hold, that whoever would convert another metal into gold, must first take away its sound.

The ninth character is, that, of all known bodies, it is the simplest; the primary elements being here out of the question. Its simplicity.

By a simple body, we mean that whose minutest part has all the physical properties of the whole mass. Thus, if a grain of gold be dissolved in *Aqua regia*, and a single drop of the solution be taken; a quantity of gold may be separated therefrom, which shall only be the millionth part of the grain, and yet have all the characters of gold. Or, if you fuse a single grain of gold with a mass of silver, and mix the whole together, so that the gold is equally distributed thro' the whole mass; you will have in every particle of the lump a particle of perfect gold, in all respects like the whole grain. Accordingly, dissolve any part of the mixture in *Aqua fortis*, and a quantity of gold will precipitate to the bottom; bearing the same proportion to the grain, that the part dissolved did to the whole mass.

Art of assaying.

And on this principle chiefly depends the art of assaying: for if you carry a mass of gilt silver to an artist, he takes a single grain thereof, melts it at the fire, to see whether the gold and silver are well mix'd; then casts it into *Aqua fortis* to have the silver dissolved, and the gold left alone. And from the proportion of the gold to the whole grain, he computes how much gold is in the whole mass.

This exceeding simplicity of gold induced the antient chemists to believe, that it was more difficult to destroy, than to make gold: for, by destroying, they meant the changing it into some other substance*.

The alchemists, however, hold their *Aurum Philosophorum* to be still more simple than our gold; as consisting of mercury perfectly cleared from all sulphur; but whether there be any such thing in nature, will admit of a question: mercury, absolutely pure, and free of sulphur, being what we must acknowledge ourselves never to have seen.

These are all the sensible criterions of gold; so that it is next to impossible to be deceived therein: for wherever these nine properties concur, there is certainly gold; and where they are all wanting, there is none.

Take, for instance, a single grain of metal pretended to be gold, and which has many appearances of it; put it along with three grains of antimony, in a cupel, and fuse it for the space of an hour: if the gold be pure, the whole grain will be found at the bottom; otherwise, the foreign, or adulterate part, will be all gone off, with the antimony: which is a proof there is no possibility of eluding, nor any danger of being deceiv'd by. Such characteristics of metals, and chiefly gold, are of frequent use in life; and especially to persons who have to do with that subtle tribe, the alchemists.

* Mr. Boyle, indeed, gives us an experiment, wherein a quantity of pure gold was so changed, and debased by the admixture of an exceeding little quantity of a certain powder cast into it, in fusion; that, beside detaching a large metalline recrement, not unlike bell-metal, the

gold itself was left of a dirty colour, and withal had lost of its specific gravity; so that, instead of 19 times the weight of water which it had at first, it was now only 15 $\frac{1}{2}$. This operation appears to Mr. Boyle almost as strange as projection. Boyle *Useful. of Exper. Philos.*

The

The Form wherein Gold is found.

GOLD is found in three different manners, or forms.

Gold found pure.

1°, In pure *glebes*, or clods, consisting of gold alone; in which form it is said to be sometimes met withal in *Hungary*: accordingly, in the emperor's collection are preserved several plates of pure gold, so found in the mines *.

2°, It is found in form of a pure dust, call'd *αυροχρυσος*. gold-dust, or *Gold-dust*. sand-gold, in the sands and mud of some rivers, brooks, &c. particularly in *Guinea*; being wash'd down from the mountains, or torn from hidden veins by the violence of waters, and gather'd up by the miserable natives †.

3°, It is also found, and that most usually, in whitish clods, dug out of mines || 150, or 160 fathoms deep, intermixed with other fossils, as antimony, vitriol, sulphur, earths, stones, and other metals; particularly silver, which is scarce ever found without a share of gold **.

Intermixed with other minerals.

In effect, 'tis very rare that gold is found pure, or otherwise than under this last form: we have specimens in our keeping from most parts of the habitable globe; but none of them pure, except those from the coasts of *Guinea*: tho' the greatest part brought from thence contains some impure heterogeneous parts; the *Negroes* being apt clandestinely to mix filings of brass or copper therewith.

* The mountains of *Chily*, also, afford gold in this form: in the clefts, or drains, between the ridges, is found a fine, ruddy earth, beneath which is a lay of blue stony matter, streak'd here and there with yellow; and under this are grains of pure gold, frequently of considerable size.

To procure the gold, they direct the current of some rivulet hither, to help carry off the incumbent earth, and lay the bed of gold bare. This done, they dig up the precious earth, and carry it to the *Lavaderos*; where, by repeated lotion, the earthy lighter part is separated, and the gold left alone. *Dict. de Com.*

† "There is also a place in *Scotland*, where, over a lead mine, near the surface of the ground, they often find large grains of native gold, free from any spar.—I have still a piece of native metal by me, which came from the same place, in weight above forty grains, wherein gold is the predominant metal." *Boyle Hydrost. Bal.*

|| "They have work'd in the gold-mine at *Cremnitz*," says Dr. *Brown*, "now up-

wards of 900 years. The mine is several *English* miles in length, and about 160 fathoms deep.—Of the ore, some is white, some black, red, and yellow.—It is not rich enough to admit any proof in a small parcel, to find the proportion of metal it contains; but they pound a very large quantity of it, and wash it in a little river running nigh the place. The whole river being divided into several cuts, runs over the ore continually, and so washes away the earthy parts from the metalline.—The common yellow earth of the country all about, tho' not esteemed ore, affords some gold: And in one place, I saw the side of a hill dug away, which had been cast into the works, wash'd, and wrought in the same manner as pounded ore, with considerable profit." *Phil. Transact.* N° 58.

** It may be added, that gold is sometimes, also, obtain'd from copper-ore; from tin-ore, from common *marcassite*, from a red earth, from sand, from *German talc*, &c. See *Boyle Useful. of Exper. Philos. and Hydrostat. Bal.*

Laz. Excker, arch-miner, and essay-master to three emperors of Germany, under whose direction were all the mines of Germany, Hungary, Transylvania, Bohemia, assures us, "That 'tis rare any earth produces pure gold; but one metal or other still grows with it: and even where it appears purest of all, it has its share of silver." He adds, as an universal rule, that where gold appears the purest, there is silver mix'd along with it; and where it is the hardest, there is both brass and silver.

Method of separating Gold.

Gold how procured from the matters it is found among.

WE have observed, that the gold dug out of mines has always some foreign matter adhering to it; particularly sulphur, earths, and other metals: whence arise several processes or operations, for the separating, or clearing it of the same.

By torrifaction and calcination.

The first is, to reverberate the mass in the fire; that is, to lay it on a grate, or grid-iron, and there torrify or roast it, stirring, and turning it continually, till all the sulphur be evaporated, and gone off in smoke. This is perform'd in the mines, by the workmen themselves; and is call'd *torrifying, fuming, and separating* gold from the sulphur.

Coc-tion.

2^o, After torrifying, and gently bruising the mass, they boil it in water, till it has lost both its taste, and smell; pouring on, from time to time, fresh water, and throwing away the old. At length, after a sufficient coc-tion, the water is pour'd out, and the gold rests at bottom. The mass at the bottom of the vessel being well dried, they try in the cupel whether it be gold or not.

Amalgamation.

3^o, If it be not, they grind the mass into powder, and boil it up with mercury and salt, for five or six days; and after 'tis ground, boil'd, and elixated, what remains, is well dried, and stoutly pounded with mercury in a large mortar. Upon this, the mercury, by its attraction and agreement with gold, draws to itself all the gold, and even the rest of the metallic part; it having a peculiar property of uniting to itself, immediately, either gold, silver, copper, or lead; tin more slowly; iron or stone never. It also joins itself to oil and sulphur; but in this case, the sulphur is supposed all taken away by the first process; and all the salt and oil elixated by the second. If these were remaining, the whole would make a sort of cinnabar; but as they are away, the only impurities remaining, beside silver, copper, and lead, are iron, and stones.

Lotion.

4^o, Things brought to this pass, the whole mass, mercury and all, is put in a large urn, or trough, and water pour'd upon it; and the whole stirr'd briskly about: out of this vessel the water is poured into another, where it is stirr'd as before; and out of that poured into a third: by which means, the earthy part is kept suspended in the water, and the heavy metallic part subsides. This operation they continue so long, and repeat so often, till the water is found perfectly clear.

5^o, What

5°, What remains at the bottom, they put in a crucible, or iron vessel, set it on the naked fire; and, after an intense heat, find all the metallic matter at the bottom, and the *scoria* at the top.

6°, The mass of metal at the bottom, they separate from the mercury, *Distillation* by adding lead thereto, and distilling the whole in a cupel; upon which, the mercury, &c. flies off, leaving only the gold and silver at the bottom: then they pour thereon either *Aqua Regia*, or *Aqua fortis*; the first dissolving the gold, and leaving the silver entire; and the latter dissolving the silver, *Dissolution* and leaving the gold entire. And by such means they are separated from each other*.

This is much the finest, and most artful way of getting gold out of the ore; tho' tis but of modern invention: had the *Spaniards* been acquainted with it, from their first settlement in *America*, they had saved immensely thereby.

Gold, 'tis commonly supposed, does not contract rust; but mistakenly: *Gold liable to rust.* for being placed in the fumes of sea-salt, its surface is grated, and dissolved thereby, and becomes rusty; the rust of a metal being nothing else but the exterior part thereof converted, by some corrosive salt, into a sort of calx, adhering to the body, in form of metalline flowers †.

M E R-

* The method here described, is that practised by the *Spaniards*, in *Peru*; but, as the quality of the ore is various, in various places, different processes are to be had recourse to. That used at *Schemnitz*, &c. in *Hungary*, is given us by Dr. *Brown*, as follows:

" They have divers ways of taking the gold out of its ore; by burning the ore, by melting it, by adding silver-ore, and other minerals, sand, and lead, as they find the ore fluid, or fix'd. Without lead, the process is thus:

" They break, and pound the ore very fine, in water; and then wash it often, and lay it in powder upon cloths, and by the gentle, oblique descent of the water over it, and their continual stirring it, the earthy, clayey, and lighter parts are wash'd away, the heavier and metalline remaining in the cloths. These cloths they afterwards wash clean in several tubs; and, after some settling, pour off the water from the sediment, washing the sediment over again, and stirring it up, in several vessels. At length, they sprinkle quick-silver on it, and knead it well together for an hour; then washing it again in a wooden vessel, after separating so much

" of it as the quick-silver does not touch, by striking the vessel against their leg, they bring the gold and quick-silver together, in an amalgama, to a corner. From this amalgama they strain as much of the quick-silver as they can; first, thro coarse cloths, and then thro finer: then put the remaining mass on a perforated plate, which they set over a deep pan placed in the earth; in the bottom whereof, they also put quick-silver. This pan they cover, and lute the cover well; then make a charcoal fire on it, and drive the quick-silver yet remaining in the gold to the rest in the bottom of the pan. Lastly, taking out the gold, they cast it into the fire, to render it purer." *Philos. Transact.* N° 58.

† The antient physicians say nothing of any medicinal virtue in gold: The first who mention it are the *Arabs*; *Avicenna* gives it mighty eulogies; but it appears, he speaks rather from conjecture than experience. The alchemists, however, have carried the thought much further: they will have this metal contain I know not what radical balm of life capable of restoring health, and continuing it to the longest period. Gold, say they, has in it a sulphur perfectly friendly to nature, like that

MERCURY, or, Quick-Silver.

Mercury.
Its weight.

THE first character or property of mercury, is, that it is the heaviest of all bodies except gold. From the table it appears, that there is no body of intermediate weight between the two; so that every body which weighs more in *specie* than mercury is gold. And still the purer mercury is, the heavier it is found; insomuch, that some philosophers hold, that mercury perfectly defecate, and purg'd of all its sulphur, would exceed even the weight of gold itself. The ordinary proportion we have observ'd, is that of 14 to 19: if any mercury be found to weigh more than according to this rate, it may be safely concluded to have gold in it.

Fluidity.

The second character of mercury is to be the most fluid of all bodies, *i. e.* its parts separate, and recede from each other by the smallest force; consequently, of all bodies, it is that whose parts cohere the least, or are the least tenacious; and therefore, of all others the least ductile, and malleable.

that of the sun, which animates the universe: and on such notions have they form'd a thousand chimerical projects, which experiment has always falsify'd.

What led the *Arabs*, and alchemists to imagine such wonderful virtue in gold, was, that they perceiv'd certain qualities therein, which they fancied must be convey'd thereby into the body: gold, for instance, is not capable of being destroy'd; hence they concluded it must be very proper to preserve animal substances, and save them from putrefaction: which is a method of reasoning much like that of some fanciful physicians, who sought for an assuaging remedy in the blood of an ass's ear, by reason the ass is a very calm beast.

Yet, no doubt but gold may have its effect. 'Tis known, that being dissolved in *Aqua regia*, and precipitated by oil of tartar, it is a gentle purgative: and the like has even been observed of gold swallow'd in substance. But there is nothing in these cases but what may arise from its mere gravity. The intestinal glands being briskly struck by the metallic parts, will be put into more frequent contractions; and by these reiterated vibrations, the humour secreted in them will be more plentifully express'd. Further, Mr. Boyle observes, that the same solution of gold being cal-

cined with flowers of sulphur, becomes diaphoretic: which suggests how much of the virtue of gold may depend on the matters it is prepared withal.

Add, that the alchemists place all their hopes in the sulphur of gold; whereas, we have a strong presumption, that there is no singular virtue in the sulphur of any metal whatever; since, when that is evaporated, any fatty matter, whether of an animal, or vegetable, will supply its place; and being added to the calx of the metal, will revivify, and give it its pristine form.

Yet does gold still retain some use in medicine. The *Aurum Potabile*, in particular, is prais'd; tho' the attempts to make it, so seldom succeed aright, that many have pronounced the preparation impracticable. Mr. Boyle, however, assures us, he had a *menstruum* which with a gentle heat would soon bring gold enough over upon a first or second distillation to afford a high, yellow, volatile tincture: But, as he could easily recover a malleable gold therefrom, he durst not pretend to do any wonders with the tincture. The same author observes, that the solution of gold applied externally, may have very considerable effects; and those of a different kind from what it has internally: of which he gives instances in the piles, and venereal disorders.

The

The parts of water do not divide so readily as those of quick-silver; and the parts of oil much less: there is a certain tenacity even in the parts of spirit of wine, which resists a separation; but there is scarce any cohesion at all, in the parts of mercury.

If you take, for instance, a single grain thereof, lay it on a looking-glass in dry weather, and in a place not dusty, and apply a lens thereto which only touches it in one point; the grain of mercury will fly into 1000 globules; each of which, upon the least touch of the lens, will again fly into 1000 lesser globules, and so on, past comprehension. And yet all these globules, tho' infinitely reduced, remain unchanged as to weight, opacity, and separability.

To be easily separable, therefore, we lay down as one of the characteristics of mercury.

Centivoglio, an eminent alchemist, introduces *Mercury* addressing a philosopher, thus: "Good alchemist, 'tis a faculty given me by nature to deceive and amuse all the world: for do but view my body; divide it into a thousand parts; turn it again, and again; and you will find that such as my outside appears, such my inside is: do what you list with me, you'll get nothing out of me, for I am immutable".

The particles of mercury, view'd with a microscope, appear perfectly smooth and polite; and reflect objects: so that looking in 'em, you see all the circumjacent bodies, as in a mirror*.

The *third property* of mercury, which indeed depends on the second, is, that of all bodies it is divisible into the minutest parts.

Thus, being exposed to the fire, it resolves into a fume scarce perceivable to the eye; but in whatever manner it be divided, it still retains its nature, and is the same specific fluid: for the vapours of distilled, or volatilized mercury receiv'd in water, moist leather, or the like, become pure mercury. And if mercury be mix'd with other bodies in order to fix it, (for it is scarce fixable of it self) it is easily separable from 'em again, by fire; and reducible into as pure mercury, as before.

The *fourth character* is, to be extremely volatile; being convertible into fumes, even by a sand-heat.

In effect, it does not sustain the fire long enough either to boil, or ignite: tho' it must be added, that if the fire be at first very gentle, and increas'd by easy degrees, it may be retained therein a pretty long time; and be fix'd, so as at length to ignite in the crucible: As we learn from some very tedious experiments made at *Paris*.

The gilders are but too well acquainted with these fumes of mercury, which frequently render 'em epileptick, and paralytick, and sometimes fa-

* Mr. Boyle proposes the applying a microscope to the minute particles of mercury; by means whereof, a globule, invisible to the best eye, will afford a pleasant and distinct prospect of all the neighbouring objects. On forms and qualities.

livate 'em; being of so penetrating a nature, as to take away scirrhus tumours; tho' very apt to reach and destroy the nobler parts.

*Incorporates
with other me-
tals.*

The *fifth property* is, that it easily enters, and intimately adheres to gold; less easily to any of the other metals; with difficulty to copper, and not at all to iron.

*But not with
iron.*

Indeed, we have heard much talk among the adepts of making an amalgama, with mercury and iron; but the experiment would never succeed with us. 'Tis possible there may be some way of binding those two bodies together; and, no doubt an amalgama might be made, by adding a large quantity of gold to the iron: but then, if the compound were beaten to a dust, the iron would wash away in water, and the gold remain.

*Its effect on
gold.*

On this account it is, that such as have occasion to handle quicksilver, always make choice of iron instruments for that purpose.

Use in gilding.

Mercury, in adhering to gold, we observe, renders it humid: thus we have known women in a salivation have their ear-rings grow white, and soft, with the effluvia of the mercury. And hence the gilders, to lay gold on any other body, dissolve it in hot mercury; which done, they apply the solution on the body to be gilt, suppose silver: then setting it over the coals, the mercury flies away, and leaves the gold adhering like a crust, to the silver: lastly, rubbing the crust with lapis hæmatites, the silver is gilt.

*Adheres to no-
thing but metals.*

It may be added, that mercury is a fluid which adheres to no body but metalline ones; unless driven thereto by force of attrition, as in æthiops mineral, where by a long, incessant rubbing, mercury and sulphur are made to mix, and stick together. And hence mercury is called the "water that wets not the hands".

*Susceptible of the
greatest degree
of heat and cold,
of all fluids.*

Its *sixth character* is, that of all fluids it is the coldest, and the hottest; supposing the circumstances alike.

We shall shew, in its place, that fire is equably diffus'd thro' all bodies; and that there is in reality the same degree thereof in mercury, as in spirit of wine: and yet if you try with your finger, mercury, in the cold, will appear much colder, and over the same fire, considerably hotter, than the spirit.

*Whence this a-
rises.*

This property depends on the great weight of mercury: for the heat and cold of all bodies, is, *cæteris paribus*, as their weights: now, mercury being 14 times heavier than water, if both of 'em be exposed in a winter's night to the same cold; the mercury must be so much colder than water, as it is heavier. * So, also, if they be both applied to the same degree of heat; while the water is barely warm, the mercury will be hot enough to burn the hands.

* Notwithstanding mercury receives such a degree of cold, its great separability, and fluidity prevents its congealing. Mr. Boyle tried various ways to bring it to freeze, by making an extream cold, and exposing an exceedingly thin skin of mercury there- to; but without effect. *Hist. of Cold.*

Thus,

Thus, in spirit of wine, we perceive a slight degree of cold ; more in water ; and most in mercury.

The seventh property is, that it dissolves in almost all acids, and unites it self with 'em : at least with all mineral acids. *Dissolves in all acid liquors.*

Thus we find it dissolve in oil of vitriol, spirit of sulphur *per campanam*, spirit of nitre, and *aqua regia*.

It is united with oil of vitriol into *turbith mineral* ; with spirit of sulphur into cinnabar ; with *aqua regia*, or spirit of sea-salt, or sal-gemma, into corrosive sublimate. Yet vinegar does not dissolve it ; and hence we are furnished with a method of detecting the frauds of druggists, &c. who make a practice of sophisticating quick-silver with lead. For, take and pound the mercury in a mortar, with vinegar therein ; and if the vinegar grow sweetish, 'tis a proof the mercury is mix'd with lead : if it have been adulterated with copper, the mercury will turn greenish, or blueish ; but if unadulterate, the mercury and vinegar will both remain without alteration. *Except vinegar.*

The eighth property is, that it is the most simple of all bodies, after gold. *To detect the sophistications of mercury.*

Accordingly we find it the same in all its parts, so far as our observation goes : if a single grain thereof be dissolved in spirit of nitre, a proportionable part of the grain will be distributed into every minute particle of the spirit : and by diluting the whole with an ounce of *Aqua stygia*, the whole grain of mercury will be recover'd*.

Had we the mercury of the philosophers, so much talk'd of ; called also *vital mercury*, *mercury of metals*, &c. 'tis asserted we would find it still vastly simpler even than gold : for, from gold, we can sometimes separate mercury, and sometimes sulphur ; but from pure mercury, nothing beside it self can be separated. Hence *Helmont* holds, that all things in nature de-

* This great simplicity of mercury, has made it pass among chemists for one of the simple, primary elements of bodies ; and even *M. Homberg*, who considers an element or principle in a stricter sense than many of the rest, viz. as a body which cannot by any analysis be reduced into simpler parts, treats mercury as an element : not but that he thinks it a compound ; but because the method of decompounding it has not been yet discovered. What puts its composition almost past question, is, that it may be destroyed, viz. by converting it into a perfect metal, and then exposing it in a large burning glass : whereas an element, or perfectly simple body, 'tis universally allow'd, must be absolutely incorruptible, unchangeable, &c. See the article of *Operations*.

The same author shews that the perfect metals are only this mercury, having its

particles or globules pierc'd on all sides, and filled with the matter of fire, or light. See the *Corollaries concerning the nature of metals*.

Mercury, therefore, may be consider'd in three different states : the first in its form of a running mercury ; the second when render'd into a metal ; the third after the destruction of the metal. In the first state it consists of little solid, smooth globules : in the second of those same globules perforated on all sides with fine foramina, by the rays of light, which are lodg'd therein. In the third of the same globules perforated on all sides, but the perforations left vacant, and by the passing of so much light thro' 'em, during the destruction, so enlarged as to run into another, and thereby leave the mercury little else but mere earth.

pend thereon; and hence it is called *Aqua immortalis*, *Aqua adeptorum*, *Aqua philosophorum*, &c.

Void of acrimony.

The ninth property of mercury, is to be free of any sharpness, or acrimony.

It shews no acrimony to the taste; nor does it corrode any body: and if a carcass were to be buried in quick-silver, it might there remain for ages without being any way hurt.

The extraordinary effects, however, it produces in the body, have given people a notion of its being acid: but the case is otherwise: when received into the blood, it only acts by its weight, and velocity; by the momentum whereof it tears and destroys the vessels, and thus occasions those great alterations, which lead the chemists into their mistake. In effect, all its medicinal operations are to be accounted for from the properties already enumerated.

The form wherein Mercury is found.

THE greatest part of our quicksilver is brought from *Friuli*, a province of *Italy*, where there are abundance of mines, belonging to the emperor*; it is here found under three several forms.

First, In ruddy glebes, or mineral clods, call'd *cinnabar*.

Secondly, In hard, stony glebes, or substances, of a saffron, and sometimes a blackish colour.

Thirdly, It is also found pure: for, upon opening holes in the beds of stones, &c. there sometimes gushes forth a vein, or stream of pure mercury, call'd *virgin mercury***.

This last sort is the most valued. *Paracelsus* and *Basil Valentine* prefer it to any other sort for chemical operations: it is supposed to have some acid adhering externally to it, and that if this could be separated, it would be-

* Mercury is either found in its own proper mines, or in those of other metals, wherewith it is intermix'd: beside the mines of *Friuli*, there are considerable ones in *Hungary*, and *Spain*. The earth, or matter it is found in, is different in the different places: In the *Spanish* mines, 'tis ruddy, streak'd with black, and so hard, that there is no digging it without gun-powder: that of the *Hungarian* mines, is sometimes, a pretty hard stone, but more usually a dark-colour'd earth, inclining to red: in the mines of *Friuli* there is a softish earth, wherein virgin mercury is found, in little drops; and a hard stone that yields the common mercury.

** Mineralists usually distinguish ano-

ther sort of *virgin mercury*; for the denomination, it is to be observ'd, is common to all mercury procured without fire. This latter is what is separated from the earth by washing with water, and passing thro' several sieves.

Mercury is also procured from certain vegetables: *S. M. Septali* gives us an account of a plant like the *doronicum*, and call'd by that name, growing in the valley between the mountains of *Turin*, near whose roots pure mercury is always found, running in small grains. He adds, that if the juice of the plant be express'd, and expos'd to the air in a clear night, there will be found as much mercury, as there is loss of juice. *Philos. Transact.* N^o. 27.

come transparent, and prove the mercury of the philosophers. Dr. Wal. Pope assures us in his travels, that enquiring of one of the directors of the quick-silver mines, wherein the difference between this, and common mercury consisted, he was answer'd, that virgin mercury, mix'd and amalgamated with gold, render'd the gold volatile; and carry'd it all away with it in fume: but this we have several times tried without success.

Manner of separating Mercury.

First, They grind the mineral glebe into powder: which done, they pour a great quantity of water upon it, stirring and working the whole briskly about, till the water become exceeding thick, and turbid: this water having stood to settle, they pour it off, and supply its place with fresh; which they stir and work as before. This they repeat, and continue to do till the water, at length, comes away perfectly clear. Then, all remaining at the bottom of the vessel is mercury, and other metalline matter.

Mercury procured from the matters it is mixed with.

By lotion.

To this mass, they add the scoria of iron; then, putting the whole in large iron retorts, distil it; by which means, all the heterogeneous metal-tick and stony part is separated therefrom, and the mercury brought over pure.

Distillation.

The virgin mercury ordinarily needs nothing to purify it, but a lotion in common water: tho', sometimes, it is so full of an arsenical matter, that they are oblig'd to strain it thro' a skin; and sometimes there is an earth united with it so strongly, that they are oblig'd to have recourse to distillation.

Virgin mercury how purified.

As to the mercury in pure cinnabar, they don't find it worth while to distil and get it out; such cinnabar selling for a better price than mercury it self.

The mercury in cinnabar.

The miserable people condemned or hired to work in these mines, all die in a little time: they are first affected with tremors, and proceed to salivate; then their teeth drop out, pains seize 'em all over, especially in their bones, which the mercury penetrates, and thus die: one of them, after he had been there 6 years, was so full of mercury, that holding a piece of gold in his mouth a little while, it became of a silver colour; and when taken out, was found heavier than before.

Mercury works.

LEAD.

LEAD.

Lead.

THE first character of lead, is to be the heaviest of all bodies, after mercury. Hence lead, fused by fire, constitutes a fluid of the third order in point of gravity; wherein all bodies, whether metalline or not, excepting gold and mercury, are suspended.

Its weight.

If all the *faces* of lead could be perfectly purged away, its weight, &c. would approach nearly to that of mercury. Accordingly, in analyzing this metal, we always find it yields a considerable quantity of mercury; tho' what the other ingredient is, united with the mercurial part, is hard to say.

Affinity with gold.

Lead, tho' the least valued among metals, has yet the greatest affinity of any with gold; at least in point of weight, which *Helmont*, and others, allow to be the most distinguishing, and immutable character of gold: and what makes the resemblance still closer, is, that lead does not mix with any metals, except mercurial ones.

Softness.

The second character is, that of all metals, it is the softest; for there is none, whose figure is so easily changed as that of lead: and hence, also, it becomes very ductile, and easily flexible; tho' not capable of being drawn out into such simple, fine, and yet coherent parts as gold.

Fusibility.

The third character is, that of all metals, it melts the readiest; the fire required to fuse lead, being not much greater than what is necessary to boil water.

In effect, it dissolves so readily, that it is not capable of ignition; and as soon as it once begins to run, the whole is in a fluor; and as soon as it begins to cool, it straight coagulates: which are circumstances peculiar to this metal.

Penetrative nature.

Hence, as it is the heaviest of all bodies that are fusible by the same degree of fire, and, of consequence, the hottest; being mixed with other metals, it facilitates their fusion. Add, that after it has continued a good while in the vessel, in its fluid state; no vessel, or instrument, is capable of containing it any longer; but it passes through them as through a sponge: and this even in a metalline vessel; which it easily ouzes thro, and at length carries away the bottom with it.

The phenomena it affords by force of fire.

A small quantity of lead being set over the fire, no sooner begins to run, than its surface appears exceedingly bright, and shines like mercury; but its face soon alters, and you discern a *nubecula*, or cloud therein, which gradually increases, till the whole surface appears cloudy, and darkened with *scoria* swimming therein in form of a dust: this dust being blown away with bellows, there straight arises a new supply; and so on, till the whole lead becomes thus converted into *scoria*; excepting a small quantity of impure mercury, which remains at bottom, and which, by further fire, is capable of being brought to a greater purity.

These

These *scoria* are only the matter of the lead gently calcined; a more violent fire vitrifies them, that is, converts them into a heavy, brittle, pellucid, elastic, sonorous matter, called *glass*; into which all metals are indeed convertible, but lead the easiest; and which is of such a penetrative nature, that it flies, without opposition, thro' all vessels, whether of metal, stone, earth, wood, or the like. As scoria.
Glass.

The calx of lead, we observe, has nothing of the appearance of lead; and yet, by only exposing it to a vehement fire, and adding to it a little iron, the lead is again separated from the mass; the rest going off in fume*. Calx.

Add, that if while the lead is in fusion, it be kept continually stirring with a spatula, it turns into a dust of a scarlet colour, called *minium*, or *red lead*: in which operation, this is further observable, that the lead becomes augmented in weight, by the particles of the fire retained and fixed therein. Minium.

The *fourth character* is, that it easily, and instantly dissolves in almost all weak acids; but very difficultly in stronger, unless they be diluted with water. Dissoluble in weak acids.

Thus, in strong *Aqua fortis*, it dissolves very slowly; and in *Aqua regia* never: but very readily in vinegar, small *Aqua fortis*, *Rhenish* wine, spirit of vinegar, &c. and even in spirit of nitre, oil of vitriol, and *Aqua regia*, if those *menstruums* be well diluted, and their acidity weaken'd with water. Add, that in whatever acid it is dissolved, the solution becomes extremely sweet, like sugar, or honey itself. Its solution sweet.

The fumes of wine or vinegar dissolve it into a white powder, or calx, called *ceruss*, or *white lead*. Ceruss.

The *fifth character* is, that it dissipates all metals melted with it, in the cupel, except gold and silver; which is a property, that had we been unacquainted with, all our treasures of gold and silver had lain in little compass: this being of principal use in the obtaining those metals. Dissipates metals melted with it.

The foundation of the process is this: "That any mass, of what kind soever, whether metal or stone, salt or sulphur; gold and silver only excepted; being mixed with lead, and exposed to the fire, flies away in fume."

Thus, if you take a single grain of gold, four grains of silver, eight of iron, and as many of lead; mix them together, with the addition of oils, salts, or sulphurs, at pleasure: put the whole on the cupel, and expose it to the fire of a wind-furnace; it will be found to dissolve, volatilize, and perish, or fly off, all to the smallest grain, excepting the gold and silver. Its use in separating gold and silver from other matters.

* Mr. Boyle contending, that the calx of the flame of spirit of wine; he found, a metal is only a magistery thereof; and that without any flux-powder, or other that the principles are not separated, but addition, by the mere application of the the bulk of the body preserved, tho' under flame of highly rectified spirit of wine, a new form; assures us he has several there would, in a short time, be obtained times, from the calx of lead, reduced a considerable proportion of malleable actual lead itself; particularly, that having lead. *Ponderab. of Fire and Flame.* once taken some calx of lead produced by

The

The particulars of the process we have already described, in the article, *Of Gold*; but there are many things worthy of notice in the trying, and refining metals by lead, which have not yet been mentioned. And,

Metals fused
together don't
range themselves
according to their
specific gravi-
ties.

1^o, It is a circumstance peculiar to metals, that, when fused together, the lighter don't swim on the surface of the heavier, but mix, and incorporate therewith. Thus, lead, for all its superior gravity, does not raise up silver, copper, &c. towards its surface; but draws*, and imbibes them intimately within its own substance, and so forms them all into one mass; as salt, dissolved in water, makes one fluid mass therewith. But, if any thing not metalline be added, it swims thereon, as wood in water. And by this means, earthy, stony, and other bodies, are readily separated together with the *scoria*, or *calx* of the lead; and the metalline parts left behind with the lead.

From lead or *Saturn's* thus absorbing the other metals, the antient chemists call'd it the *devourer of his sons*, &c.

Glass of lead
not reducible
into lead again.

2^o, The lead which, in the operation just deliver'd, escapes thro' the pores of the cupel, passes, as already noted, in form of a *glass*, which is not capable of being restored, by any known means, into lead again: whoever could find a way of doing this, would reap immense riches from it; there being abundance of minerals which have gold and silver in them, tho' in such small proportion as not to compensate for the great quantity of lead consumed in making the separation. *Glauber* and *Becher* have attempted this restoration of lead in various manners, but without success.

Litharge.

3^o, If lead be fused with pure gold, the calx or spume which it rises into, and which is usually blown away with bellows, is called *litharge*; which, if it be but slightly tinged, so as only to appear of a pale colour, it called *litharge of silver*: but if it be further coloured, so as to grow yellow, it is term'd *litharge of gold*. And if this litharge be not blown off the test; but remaining there, be further urged by fire, it penetrates, as already observed, thro' the pores of the cupel, and escapes in the form of glass. So that it is to be allowed no inconsiderable property of lead, that under such circumstances it is incapable of being confined in any vessel or prison whatever; which, no doubt, was what occasion'd the antient chemists to denominate it *Tortor Gehenna*. A vessel wherein this vitrified lead would be contained, is another of the *Desiderata* in chemistry; the discovery whereof would be an ample fortune.

Desideratum.

We shall add, that if any alchemist can make a matter, which being cupel'd with twenty-times its quantity of lead, can be retained till the mass shines, he will have real gold or silver. And to detect the vanity of any one's pretensions to the secret of making gold or silver; you need only take a grain of his matter, melt it with two drams of lead; and if it re-

* Sulphur readily joins with lead, and renders it friable; arsenic, in particular, volatilizes it; and it admits of a mixture with tin: but iron it does not mix withal, unless that metal be first reduced to a calx. M. *Stball* takes one of the main reasons hereof to be the lightness of iron. *Nouv. Cours de Chymie*.

main behind in the test, 'tis gold or silver; otherwise not. So incorrupt, and infallible a judge is *Saturn*: whom we accordingly find called the *bath of the king and queen*, or of the *sun and moon*; wherein being immerfed, they lay aside their garments, and arife the purer; while every thing else is drowned.

Centivoglio having introduced an alchemist seeking the philosopher's stone, and supposing him fallen asleep, *Mercury* addreffes him thus: "What wouldst thou make of me? Gold; replies the alchemist. That might be, says *Mercury*; but that here's a lame old fellow, [*Saturn*] who will make a bath of his own urine, wherein he no fooner washes me than I shall fly away again, and be lost in air."

Centivoglio goes on, "that his alchemist was in a garden wherein grew all kinds of apples; but six trees of fairer fruit than the rest; and that *Saturn* tasted of them all, but there were only two that he fancied; and these two, after washing them in his urine, he proclaimed the fairest of all bodies." The meaning of these allegories is obvious enough.

Upon the whole, there are three ways, whereby all the matters mixed with gold and silver are destroy'd, and lost, when cupel'd with lead: ^{Heterogeneous matters mix'd with gold and silver, carried off by lead divers ways.} 1°, By volatilizing, and evaporating. 2°, By degenerating into *scoria*, and retiring to the sides of the test in form of dust. 3°, By penetrating the pores of the cupel; which only happens to such bodies as can neither fly off in fumes, nor work to the sides in the way of *scoria*.

The sixth character of lead, is, that of all metals it is the least sonorous, and elastic; and that it diminishes the sound of other metals, when mixed therewith. ^{Lead the least sonorous of all metals.}

This property follows from its softness: for if two equal leaden balls be struck with equal velocities against each other, they will both remain fix'd in the point of contact, without any vibration, or resiliation at all: so that of course no sound can be produced. 'Tis on account of this unelasticity of lead, that it has been used by *Dr. Wallis*, *M. Huygens*, and others, for determining the laws of percussion.

By this property lead should appear to be nearly allied to gold, which is the least sonorous, and springy of all metals, except lead. ^{Its affinity with gold.} Accordingly, several experiments have been produced, to prove that lead melted always either contains, or generates some portion of gold. *M. Homberg* assures us, that taking a quantity of silver, and separating it from all heterogeneous matter by a fusion with lead; and after the fusion, putting a piece of it in *Aqua fortis*; a little gold fell to the bottom. And upon adding some copper to the *Aqua fortis*, the silver was precipitated.

Such are the properties of lead, hitherto discover'd: but a person, who had time enough to examine this metal more thoroughly, in a place ^{Our knowledge of it yet very imperfect.} where there were plenty of it to be had, at an easy price; as among the *German* mines; we have several reasons to imagine, might discover many things therein, of a different kind from any thing yet known; and which might redound not a little to his advantage.

Manner in
which lead is
found.

Lead is sometimes found pure ; but chiefly otherwise : and particularly in mines *, and chiefly those in large mountains ; of which kind there are abundance in *Germany, Hungary, and England*. Its ore †, or mineral, is a sort of blackish, fatty earth, which makes it difficult to fuse ; but the fusion being effected, the lead is pure without further preparation. The process is thus :

Method of se-
parating it from
the ore.

The ore, or matrix of the lead being found, is stratified with coals, and so calcined, or fused with a vehement fire, till such time as the coals have taken away all its sulphur ; which would otherwise prevent its malleability. What remains of the mass, is lead ‖.

Kinds of lead.

Lead is distinguished into *common, or malleable lead* ; which is what we have hitherto spoke of : and *black lead*, or lead of the philosophers ; which is *antimony*.

* The ore is of a poisonous quality, especially with regard to brutes : " They who live near where it is wash'd," says Mr. *Beaumont*, " can neither keep dog, nor cat, nor any sort of fowl ; but they all die in a short time." He adds, that " not only calves, but even children have been known to be kill'd, by only being in houses where lead-ore had been kept some time : And that if any sort of cattel feed often on the grass on which the steam which rises from the smelting of lead falls, they all die soon after." *Phil. Collect. N° 1.*

Yet Mr. *Glanvil* informs us, from some experienced mine-men, that in the *Mendip* mines, the vein of ore has sometimes been known to run up into the roots of Trees ; without any observable difference in the top of such trees from other. *Ubi supra.*

† There is a very considerable difference between the ores of different mines : " Some," says Mr. *Boyle*, " is so like steel, that the workmen call it *steel-ore* ; which being of more difficult fusion than ordinary, they mix other ore with it. There is another, which, from its aptness to vitrify, and serve to glaze the potter's vessels, is called *potter's ore*." *Useful. of Exper. Philos.*

The same author, elsewhere, reduces all our *English* lead-ores to three classes : The first, those which in the ordinary ways of melting afford from thirty to forty pound of metal, for every hundred pound of ore. The second, from forty-five to sixty. The third, from sixty to eighty. *Med. Hydrostat.*

The lead of very many mines, being skilfully treated, affords silver ; but the quantity of silver, in ores, does not hold in proportion to the quantity of lead. Mr. *Boyle* caused some lead-ore to be tried, which being the most promising he had ever known, gave him hopes of some considerable quantity of silver : but, tho' it prov'd so rich in lead, as to afford after the rate of seventy pound to the hundred ; yet one of the most expert artists in *Europe* could not extract one grain of silver from it. *Useful. of Exper. Philos.* Yet a piece of lead-ore was brought him from *Ireland*, which seem'd so light in the lump, that he thought it scarce deserved to be wrought for lead ; which, however, was found, upon trial, so well stored with particles of silver, that he encouraged the owner of the mine to work it. *Med. Hydrost.*

‖ In those celebrated lead-works at *Mendip* in *Somersetshire*, the method of procuring the metal is thus deliver'd by Mr. *Glanvil* : " When they have got the ore, they beat it small, then wash it clean in a running stream ; and then sift it in iron rudders : then they make a hearth or furnace of clay, or fire stone, and therein build their fire, which they light with charcoal, and continue with young oaken gads, blown with bellows, by mens treading on them. After the fire is lighted, and the fire-place hot, they throw the lead-ore on the wood, which melts down into the furnace ; and then with an iron-ladle take it out, and cast it in sand into any form they please." *Philos. Transf. N° 39.*

S I L V E R.

THE first character of silver, is its weight, which comes next to that of lead; being to that of gold, as 10 to 19; and to that of water, as 10 to 1. *Silver. Its weight.*

It falls short, therefore, of mercury, and consequently is but little disposed to become gold; unless we had a method to make it a great deal denser, and more compact. And hence it is that the alchemists hold it more easy to make gold of mercury, than of silver; and laugh at novices for attempting to convert silver into gold. *Not disposed to become gold.*

The second character is its fixedness in the fire; in which respect it goes beyond all known bodies, except gold*. *Fixity.*

This appears from an experiment of the prince of *Mirandula*, who placing a quantity of silver in the eye of a glass-furnace, kept it in continual fusion for the space of two months; then taking it out, found it to have lost only $\frac{1}{11}$ part of its weight.

Mr. *Boyle* even assures us, from experiments of his own, that silver, laid in the eye of a glass-house furnace, scarce loses any thing of its weight: tho', in an experiment made by Dr. *Halley*, after the silver had been in the focus of the furnace for two months, it was taken out with a diminution of $\frac{1}{11}$ of its weight; as in the prince of *Mirandula's* experiment.

But 'tis highly probable, that the silver used in the first, and last of these experiments, was not pure; nor perfectly purged of tin: for Mr. *Boyle* taking out his silver at a fortnight's end, found it to have lost something: but after that, tho' exposed a long time to a very violent fire, he could not perceive it to lose any thing at all; the tin, which is exceedingly difficult to separate from silver, having been all carried off by the first fire**.

The third property is to be the most ductile, and malleable of all bodies after gold. *Ductility and malleability.*

* Mr. *Boyle* observes, that tho' silver be one of the most fixed of all bodies, it may be possible, by a mere change of texture, to render it volatile. To confirm this, he instances a calx of silver made by a solution of the metal in a peculiar menstruum, which, to his great surprize, upon exposing it even to a gentle heat, presently flew away in form off a *Farina volatilis*, whitening the neighbouring part of the chimney, &c. *Mechan. Orig. of Volatil. and Fix.*

** Silver, exposed to the focus of a large burning-glass, crackles, emits a copious fume, and is at length cover'd pretty thick with dust, or calx; which dust, if the silver have been refined with antimony, is of a yellowish cast, and by the further action of the solar fire, will vitrify like gold: but, if it have been refined with lead, the calx proves of a whiter dye, and never vitrifies. *Memoirs de l'Academ. A. 1702.*

Our wire-drawers use to stretch out silver to an incredible fineness; in-
somuch that a single grain, for instance, they will draw out into a thread
of nine yards long; which thread is still capable of being beat into a leaf
two inches broad, and yet still cohere.

Fusibility. The fourth property is, that it easily dissolves by fire; much more easily
than either copper or iron, tho' more difficultly than either gold or lead;
and runs e'er it ignites.

Dissolubility. The fifth property is, that it is dissolvable in *Aqua fortis*; and not in *Aqua
regia* *.

In what men- struum. *Aqua regia*, we have already describ'd, with all the species thereof; and
have shewn that sea-salt is the basis of 'em all. *Aqua fortis*, on the other
hand, is always made of nitre; nor is silver dissolvable in any saline men-
struum except what has nitre in it: not in sea-salt, nor spirit of sea-salt,
nor *Aqua regia*, nor oil of vitriol, nor sal-gem, nor sal-armoniac, nor spirit
of sulphur *per campanam*, nor spirit of alum, nor vinegar, nor any other acid,
or alkaline salt or juice. In effect, sea-salt, sal-gem, and salt armoniac are
the only dissolvents of gold; and nitre the only dissolvent of silver.

Aqua fortis. Nitre fused by fire does not touch silver; but if it be mix'd with some
body that prevents its liquefaction, and expos'd to a violent fire, it resolves
into fiery vapours, which being caught and condensed in a receiver, is deno-
minated *Aqua fortis*.

How prepared. In this distillation of nitre, the principal things added, to prevent its fu-
sion, are, 1. sand, 2. vitriol, 3. alum, or, 4. alum and vitriol together. If some
of these be not mix'd with the nitre, it readily runs; in which case, the
fire acting equally on all the parts, does not change 'em sufficiently, or con-
vert 'em into spirit. But, when the fusion is prevented, the parts of the
nitre receiving more violent impressions from the fire, are exalted into
a volatile spirit. Now alum and vitriol, when well dried, are not capable of
being fused by any force of fire; and therefore mix'd with nitre suffice to
prevent its melting.

To prove its pu- rity. If to the spirit of nitre thus distilled, be added sea-salt, or sal-armoniack;
it will no longer dissolve silver, but gold: and hence, if you would try
whether *Aqua fortis* be pure; take a single grain of it; and put a like quan-
tity of pure silver, dissolved in *Aqua fortis* therein. If, now, the solution remain
without either the water's turning milky, or the silver's being precipitated;
you may be assured the *Aqua fortis* is pure; for if it had the smallest grain
of sea-salt, or sal gem, the liquor would become milky, and the silver fall
to the bottom.

* Yet M. Homberg has had the fortune to discover, by a happy mistake, that *Aqua
regia*, under some circumstances, will dis-
solve silver, and not gold. The phlegm
which arises first in distilling *Aqua regia*,
he observes, is a true *Aqua regia*, and yet
this, if taken when newly made, and after
it has been some time in digestion with gold,
will dissolve silver, without touching gold;
tho' without these two circumstances, it
has the very contrary effect. *Memoir. de l'A-
cademie, An. 1700.*

Here

Here seems, therefore, to be a sort of natural repugnance; which is found of the utmost use; in regard that without it, we should want a method of separating gold from silver: 'tis true, they may be separated by antimony; but then the silver all flies away and is lost; and as for lead, it only separates every thing else from gold and silver, leaving them together as it found them*: but dissolve a mass of gold and silver in spirit of nitre, and whatever falls to the bottom is gold, and what is retained is silver; or dissolve it in *Aqua regia*, and what falls to the bottom is silver.

Its use in separating silver and gold.

The sixth property is, that it resists the force of lead, in the cupel; nor is at all hurt thereby, but comes out the purer.

Silver sustains the force of lead.

Thus if 100 pounds of pure silver be fused along with lead; the latter will all evaporate, or be blown away; and the silver remain behind without any diminution of weight.

The seventh property is, that it does not resist the force of antimony; but volatilizes, and flies off along with it.

But not the force of antimony.

Whence this should proceed, is not easy to assign: antimony, we know, is corrosive, to a great degree; so great, that it volatilizes all metals, except gold; and carries 'em off in fumes. There is, therefore, a very notable difference between the nature of gold and silver; the former resisting lead, and every thing else; the latter, too, resists lead, but not the lead of the philosophers. And hence that denomination of antimony, *balneum solius regis*.

The eighth character is, that when well purified, it does not yield much sound; being less sonorous, and its sound more obtuse than that of iron, or copper; tho' more than that of gold.

Its sound.

Silver** is scarce ever found pure, and free of all heterogeneous admixture: we meet with it in almost all sorts of other minerals; sometimes in the ore of gold, † sometimes in that of lead, and that of cop-

In what forms it is found.

* M. Homberg has hit on another way of separating gold and silver; viz. by putting the mass in a crucible, with equal parts of salt-peter and decrepitated salt at the bottom thereof, and setting the whole to fuse in a melting furnace, by a gentle fire, for the space of about a quarter of an hour.

The effect, he accounts for, by supposing the salts, e'er they be in perfect fusion, to sustain the mix'd metal, when it begins to melt, and serve as a kind of sieve to it, letting the heavier part of the gold pass thro', and retaining the lighter the silver, which does not fuse so soon. So that if the crucible be taken from the fire at the proper juncture, the silver presently hardens, &c. In the mean time, the salts being but imperfectly fused, prevent the silver's falling down and re-mixing with the gold. *Memoir. de l'Academie. Ann. 1713.*

** Most countries in all the quarters of the world, afford silver mines; but Peru and Chily above all others: the mines of Potosi in particular are said to be inexhaustible; being dug now with almost as much success as when at first discover'd; abating this, that the vein then lay, as it were, on the surface of the ground, but is now got to a frightful depth, being descended to by 4 or 500 steps.

† Mr. Boyle dissolving some of the purest gold in amenstruum, which he calls *peracutum*, found, at the bottom of the solution, a whitish powder, which being fused into a metal, prov'd true silver. And reducing the dissolved gold into a body again, and dissolving it a second time; he procured more. *Of Forms and Qualities.*

per,

per; || but ofteneft in a kind of black ftony glebes, full of fhining ftreaks. It has *† a corrofive fulphur, or bitumen, always found attending it; which turns yellow in the fire, and has fomewhat of the effects of antimony; and perhaps has fome antimonial parts in it, being found to volatilize the filver, in the cupel, and ftal it away in fume: whence the alchemifts denominate it *Fur, thief*.

And hence the difficulty of procuring it.

The lofs in this refpect is very confiderable; efpecially if the mafs, or ore be very crude; fo that the utmoft care is to be taken in making the feparation: for a mafs of this kind being put in melted lead, the fulphur will, indeed, be all carried off; but then the point is fomewhat delicate; for if the fire be too intenf, the filver is apt to go along with it; and if the fire be too flack, the fulphur will be left behind.

Defideratum.

'Tis certain, many thoufand pounds worth of filver have been evaporated and loft in the feparation; nor is there any thing more wanted in the art of metals, than fome matter which would feparate fulphur from filver, without diminution. The procefs of feparating, which now ufually obtains, is thus.

Manner of feparating and purifying of Silver.

Silver feparated by torrefaction or calcination

A Quantity of the filver glebe or ore is firft torrifed, or calcined in a furnace, by a gentle fire; ftirring it from time to time; and taking care the fire be not fo great as to melt and make the fulphur carry away the fil-

|| See what has already been mention'd of the procuring of filver from lead, in the notes, p. 82.

A friend of Mr. Boyle's brought him fome ore, found in his own grounds, which appear'd to be copper ore; as indeed, after fuſion, it did yield a very good copper; but the perfons to whom he committed the examination of the mine, being very ſkilful, found in the ore, not only copper, but in the copper a confiderable quantity of filver, and in the filver a good proportion of gold.

'Tis not eafy to determine, whether the gold and filver thus obtain'd from divers matters, were really contain'd therein, or are made by the operation. A man would ſcarce imagine that there were iron in plants, and yet their afhes afford ferruginous corpufcles which the load ſtone attracts. But of this we have ſpoke more at length in the notes, p. 60.

*† The mineral ſtones dug out of the mines of Peru are of different colours, qualities, hardneſſes, &c. ſome are white, or greyiſh mix'd with red or blueiſh ſpots,

call'd *Plata blanca*; others black, call'd *Plomo renco*, which is the richeſt and the eaſieſt wrought. The *Rofficer*, tho' rich, turns red when rubb'd againſt iron. The *Zorock* ſhines like talc. The *Paco* is of a yellow red, extremely ſoft. The *Cabrillo* green, and almoſt friable. Laſtly, the *Aramea*, which is no where found, but in a ſingle mine at *Potoſi*, conſiſts of threads of pure filver, interwove ſomewhat like a ſilver-lace that had been burnt for the filver.

The working of theſe mines, is exceeding dangerous, on account of the exhalations they yield; which are even felt a good diſtance off; and not only ſuffocate the miners, but even the cattle grazing in the neighbourhood. Scarce any of the workmen can bear ſo peſtilential an air above a day together. It ſometimes proves ſo mortal, that they are oblig'd to ſtop the mines up again. The mines of *Potoſi* are reckon'd the moſt innocent; and yet it were impracticable to work even theſe, but for the herb *Baraguay*, an infuſion whereof, taken much as Tea is among us, ſerves for a ſort of preservative

ver.

ver. The sulphur thus insensibly consumed; they grind the mass into a powder; and cast huge quantities of rain-water thereon; taking care to *Lotion* stir and agitate it sufficiently to separate all the lighter parts, and make 'em swim a-top. After it has stood a while to settle, they pour off the water, with all that was sustain'd therein; and pour on a fresh quantity: this they stir, and throw off as before; repeating the process till all the lighter, earthy matters are clear'd off, and nothing left at bottom but metal, with the heavier stones, &c.

To separate these, they put the mass into melted lead, over a fire sufficient to carry off the remaining sulphur, yet not so intense as to carry the silver along with it; and as mercury has a property of drawing silver to it self, they add a quantity of hot mercury to the melted lead: by which means the whole metallic matter becomes amalgamated, or fix'd in a mass, exclusive of the stones: tho' the sulphur must all have been well clear'd out in the first place; otherwise the mercury will not attract the silver, but dissolve and mix with the sulphur, and form cinnabar. *Addition of lead and mercury.*

The next step is to dilute and grind this amalgama, or mass of mercury and silver, in water; then they distil it in a retort; by which means the mercury all rises and evaporates, and the pure silver remains in a powder at bottom. *Distillation.*

By the like method it is easily found whether, or no, there be any silver in a given mass. Some, instead of calcining the ore, to consume the sulphur, grind it up with iron filings; and when in fusion, cast in some fix'd salt, which drawing and absorbing the sulphur, goes off in scoria, and leaves the metal alone*.

C O P.

* In the silver works of Peru and Chili the method of separating the silver is somewhat different. After first breaking, and then grinding the ore by a water-mill, they sift it in iron riddles, and mix it up with water, into a paste: This, after half drying it, they cut out into square pieces of about 2500 lib. each, call'd *Cuerpos*; and bake 'em over again with sea-salt, which melts and incorporates therewith. This done, they sprinkle mercury on 'em, and bake 'em a third time, till the mercury be well incorporated with the whole substance of the silver. This operation, which is exceedingly dangerous, falls to the share of the poor Indians, who go to it eight times a day. To promote the effect of the mercury, they add lime and lead, or tin ore, and in some places even make use of fire.

When the amalgamation is completed, they carry the mass to the *Lavaderos*, which are three basons, placed a-slope, so that

they empty successively out of one into another: the *Cuerpos* being thrown into the uppermost, and the stream of a rivulet turn'd upon it, the lighter, earthy part, is separated and carried off; which is forwarded by an Indian treading all the while upon the mass. When the water goes off clear, the silver is found at bottom, incorporated with the mercury; in which state it is call'd *Pella*. To get out the mercury again, they put up the *Pella* in woollen bags, press it hard, pound it lightly, and at last fall it in a sort of wooden mould, or trough, perforated at bottom like a cullender; and now the mass is call'd *Pinea*.

The *Pinea* being taken out of the mould, is then laid on a copper plate full of holes, over a trevet, under which is a large vessel of water; and the whole cover'd with a capital of earth, which they surround with fire. By this means, the mercury remaining in the *Pigne*, is first volatiliz'd,

COPPER.

Copper.

THE first character of copper, is, its specific gravity; which, as already noted, comes next that of silver; being to that of gold as 8 to 19, to that of water as 8 to 1, and to that of silver as 8 to 10.

Its weight.

Ductility.

The second character, is, that when pure, it is very ductile, * and of a beautiful red colour, exceeding that of gold. We are not here speaking of the yellow copper, called brass, and *aurichalcum*, which is a factitious metal prepared of copper melted with *Lapis calaminaris*.

Fusibility.

The third character is, that it continues long fix'd in the fire, e'er it flies off; almost as long as silver; much longer than either lead or tin: tho' at length it evaporates, and loses much of its weight.

Fusibility.

The fourth character is to be difficult of fusion; much more so than silver: and yet it ignites before it fuses; the contrary of which happens in silver.

The danger that attends the fusion.

It must not be omitted, that if, when copper is fused, a single drop of water do but fall upon it; or if the moulds, vessels, &c. it is cast in, be but ever so little moist; it flies into a million of fragments, with an incredible noise, and destroys all the persons near it. For this reason the Swedish miners are very cautious of admitting any body to be present at the operating; lest chancing to spit, sneeze, or the like, they bring instant destruction on 'em all.

Diffoluble by all salts.

The fifth character is to be dissoluble, by all the salts known; both acid, alkaline, and nitrous; nay even by water, air, &c. consider'd as they contain a proportion of salt.

Erugo.

The dissolution shews it self by an *erugo*, or rust covering the metal; which when view'd with a microscope, appears a congeries, or cluster of crystals, of different colours, according to the salt that produc'd 'em: thus copper suspended in the vinegar-houses immediately contracts a rust, and grows green; and the same is effected by common and other salts, which

liz'd, and rais'd; and then precipitated again into water, where condensing, it forms a number of grains of silver of different figures, sticking to each other. And 'tis in this form, the workmen endeavour elandefinely to sell the silver to foreign vessels, trading in the South Sea. *Dict. de Commerce*.

* The extreme divisibility of copper exceeds all imagination; Mr. Boyle making a solution of a single grain of metal, in spirit of sal-armoniac, found it would give a blue colour to 256806 times its own bulk of clear water; nay, a manifest tincture to above 385200; and a faint, yet discernible

one, to above 530620 times its bulk. *Subst. l. of Effluvia*.

Mr. Boyle assures us, that by the help of zink, duly mix'd after a certain manner, he has given copper as rich a colour as ever he saw in the best gold. *On Colours*.

|| To make brass, they calcine, and pulverize the calamine, then mix it with a little charcoal dust: seven pound of this mixture, they put into a melting pot, with about five of copper over it. Then, letting it down into a wind furnace; after 11 hours it is drawn up again; the brass being complete.

being

being sprinkled over the most polish'd copper plate, turn it rusty in a day's time. Nay, oils themselves dissolve copper; witness oil of olives, &c. but it must be added, they do this by means of the salt contain'd in 'em*.

Add, that if melted sugar, saliva, a syrup, &c. do but touch copper they dissolve it, and become vomitive.

Copper dissolved by acids, turns green; by alcalies, red; and by the intermediate salts, blue. Different colour of its solution.

If the rust be held to the fire, till the dissolvent is dried and evaporated; it grows blackish, and is call'd the *calx* of copper.

From this common reception of all menstruums, copper is call'd by the chemists † *Venus*, i. e. *meretrix publica*, a common prostitute. All other metals have their peculiar dissolvents, but this is dissolved by all. Whence the name Venus.

The sixth *character* is, not to resist either lead, or antimony; but, if long expos'd to the fire, in the cupel, to fly off with 'em, and disappear. Copper volatiliz'd either by lead or antimony.

The seventh *character* is, that of all metals it is the most elastic, and sonorous; and on that account is commonly us'd for the strings of musical instruments, as also for trumpets, &c. Its elasticity and sound.

The eighth *character* is, that it remains long fix'd in the fire; tho' at length it emits a white poisonous fume, and loses a deal of its substance. Fixity.

'Tis a thing of the last importance to a physician, to be well acquainted with the nature and properties of copper; as it furnishes a great variety of remedies, for various occasions. Medicinal virtues of copper.

It may be even said, that all which *Paracelsus*, *Helmont*, *Boyle*, &c. have laid down of an universal remedy, seems understood of copper.

Thus the famous *Butler's stone*, if there be any truth in it, was compos'd of a preparation of this metal: that much celebrated remedy of *Van Helmont* is known to be no other than sulphur of vitriol or *Ens* of vitriol, fix'd by a long calcination and cohobation. Mr. *Boyle's Ens Veneris* is made of *Ens* of vitriol of *Venus* restor'd by sal-armoniac. It cannot be denied that copper is an excellent emetic, having this singular virtue, that it exerts its force as soon as ever 'tis taken; whereas other emetics lie a long time dormant in the stomach, creating nausea's, anxieties, &c. But a single grain of verdigrease immediately vomits; and hence, syrups, &c. which have stood all night in copper vessels, excite vomiting. 'Tis also of excellent use for deterging of old ulcers, and of approv'd virtue in chronical and hydropical cases; accordingly we read, that a celebrated physician recover'd *Charles V.* of a dropfy, by the mere use of copper. In effect, when its vomitive

* Mr. *Boyle* found that oil of sweet almonds, nay even milk it self, would make a kind of dissolution of crude copper. On all males, i. e. all acid salts; the chemists calling all acids, males; and alcalies, females.

† Others will have the name *Venus* more

tive virtue is spent in the body ; it acts by its sulphur, which is of a very penetrating nature, and highly narcotic, assuaging pains, &c.

Where copper is found.

Copper is found in divers places, both in *Europe, Asia, and America* ; but the most abundantly in *Sweden, and Germany* ; where there are whole mountains of it. Indeed, it may be observ'd in the general, that there is scarce any earth, in any part of the globe, but what has a share of copper in it. 'Tis sometimes found in substance, but oftner in hard stony glebes*.

The richest copper mines are in *Hungary* ; where the mineral matter contains $\frac{1}{4}$ part of pure copper.

Wherever copper is found, there is always found vitriol ; and that generally of all the three kinds, viz. green, blue, and white ; and hence the class of *vitriols of Venus, or copper*. Along with copper are likewise found the richest and brightest-colour'd gems, as emeralds, turquoises, and the like green and blue precious stones.

Separating of Copper from the Ore.

Difficulty of separating it from the ore.

THE procuring, or separating of copper from its glebe or ore, is very difficult ; to which difficulty it is, that the great price the metal bears, is wholly owing. For 'tis found in such abundance, that were it not for this, it might be sold for almost nothing ; but it adheres so strongly to the stony matter, that 'tis a wonder it should ever be separated at all.

Ercherus says it must pass thro' 14 furnaces † e'er it be pure. So long as any of the stony substance adheres to it, it remains friable : But a portion of that is separated and cast off at every fusion ; till, at length, after the fourteenth fusion, it is all extracted, and the metal left red, and malleable.

* Copper ore is sometimes, also, found in form of a dust, or powder ; and sometimes procured from the water of certain rivers. The stony glebes, again, in which it is ordinarily found, are of different qualities, some blue, others green, &c. In the mines of *Hungary*, *Dr. Brown* observes, there are divers sorts of ore, but the chief difference is between the yellow and the black ; the first whereof is pure copper ore, the black also contains a portion of silver. *Phil. Transact. N° 59.*

† E'er they go to fusion, they first wash it well, to separate the looser earth ; and when fused, cast it into moulds call'd sal-

mons. What is obtain'd by the first melting, is the copper commonly used : for particular occasions, they have recourse to repeated fusions. According to the different matters wherewith the metalline part is combin'd, different things are added to the ore, in fusing, to carry off the same.

In the *Hungarian* mines, *Dr. Brown* tells us, they sometimes burn the ore, and sometimes melt it ; and this, sometimes by it self, and sometimes mix'd with other minerals, and its own dross. He adds, that an hundred weight of ore will yield 20, 30, 40, nay 50, and 60 pound of metal. *Phil. Transact. N° 59.*

IRON.

I R O N.

THE first character of iron is, that it is the heaviest of all bodies, after ^{Iron.} copper. ^{Its weight.}

Its second character is, to be the least ductile, the hardest, and most brittle ^{Brittleness.} of all metals.

Yet, by fusing it, we can render it still harder, and more brittle, and scarce capable of being drawn or extended at all: or, if it be only ignited, and then quenched in cold water, it grows harder, and loses much of its former degree of ductility; and the more so, as the water is colder, and denser, and the extinction more sudden.

This extraordinary brittleness of iron arises from the great quantity of sulphur intermixed with it: we find a degree of sulphur in all metals: ^{Whence that arises.} and the greater that degree, the more brittleness does it impart to the metal. The abundance of sulphur in iron is apparent from the sparks it emits, when ignited, and beat under the smith's hammer; those sparks being only the sulphur of the iron: nor is there any thing like them seen in any other metal.

Iron being well purged of its sulphur by a vehement fire, becomes ^{Steel.} harder, compacter, and somewhat lighter, and is called steel*.

The third character is, that it is very fixed; we mean as to its metalline ^{Fixity of iron.} part, not its sulphureous one. This

* The business of steel remains somewhat obscure: the naturalists, from Aristotle to our time, speak of the making it, in terms which leave a man greatly to seek for the precise method thereof. It seems the artists have had the address to elude their inquiries; and still keep somewhat of the mystery with themselves.

Aristotle says, That steel is only iron defecated, and made pure by repeated fusions; for the impure parts, or scoria, he observes, subsides, and are purged off by the bottom. Meteor. l. 4. c. 6. And the like account is given by several later writers. But Dr. Lister shews they are all mistaken: iron, of itself, he notes, how oft soever purged, and refined, will never become steel, without other addition. *Philos. Trans.* N° 203.

The chemists, with the generality of later writers, as Dr. Plott, &c. will have steel made by keeping the iron ignited some time, amidst the fire, and fume of bullocks horns and hoofs, and charcoal made of beech, or willow; and then plunging it in cold, astringent decoctions. But these additions appear to be no better than a blind; they are necessarily

required for case-hardening of iron, which may have led authors into the notion; but don't contribute any thing to the converting it into steel.

Kircher, and Agricola, describe the method of making steel, as practised in the island of Uva, a place famous from antiquity for this metal: "The iron is first heated red-hot, then cut in small pieces, and thus mixed with a sort of stone which promotes the fusion: then, a crucible is set in a smith's forge, and fill'd with charcoal. When the vessel is red-hot, they put in, by little and little, the mixture of iron and stone. As soon as 'tis melted, they thrust three or four pieces of iron into the middle thereof, and keep them boiling therein, by a strong fire, five or six hours; observing, from time to time, to stir the melted metal, that the pieces of iron may imbibe the smaller, subtler particles thereof, and have their own grosser particles attenuated thereby. Lastly, taking out the pieces, they forge them, and draw them out into bars; and thus, hot as they are, plunge them into cold water: taking them out from

This latter is pretty easily volatilized, and consumed by fire, as appears from the sulphureous smell of iron, either ignited, or melted. If you expose iron to an intense fire, it grows warm, reddens, commences of a flame-colour, and at length emits sparks, and then runs. If it be now taken away, it will be found softer for the fusion: but if you continue it in the fire, it comes at last to yield a whitish fume; and thus loses a great part of its body, viz. all the sulphur.

Fusibility.

The *fourth character* is, that it ignites long e'er it fuses; and fuses with much difficulty: and that, contrary to the nature of all other metals, the more it is ignited, the softer, and more ductile it becomes; being scarce flexible or malleable at all, till after ignition.

Add, that when in a state of ignition, both its weight and dimensions are greater than when cold*. This accession of weight arises, no doubt, from the fiery particles fixing therein: and if, when ignited, it be prevented from extending itself, it bursts; and either breaks, or throws off any body that restrained it.

Diffusibility.

The *fifth character* is, to be dissoluble by almost all bodies in nature; all, we mean, that have any degree of activity, as salt, dew, the breath, fire, water, air, &c.

Its rust.

By the action of any of these, it contracts a *rubigo*, or *rust*; which is nothing but the flowers of iron; or iron dissolved, and relinquished by its dissolvent: for iron, being examined in a microscope, when first it becomes rusty, shews its surface cover'd over with a number of pellucid, vitriolic *lamellæ* or gleans; which being afterwards dried, by the fluid menstruum's evaporating, become a ruddy calx.

How prevented.

Hence, a fatty, or oily matter, perfectly destitute of all salt, or acidity, being smear'd over iron, hinders its contracting rust; by preventing the access of the air, and water; the salts floating wherein, would corrupt it.

And hence the method used by our artificers to preserve iron pure, and bright; viz. by boiling oil of olives with a little litharge, or ceruss; by which the acidity of the oil is absorbed: or, they only boil their oil to a thickness; and so exhale the acid.

"hence, they are found steel; tho' not so perfect, but that they frequently make them undergo the process a second time; first casting in some fresh matter into the crucible." *Agric. de Re Metal.* lib. 9.

Upon the whole, we may observe, that the charcoal appears the most essential thing in the operation, as being the only constant ingredient in each method: accordingly, we have even reason to apprehend it the only essential; as having ourselves made tolerably good steel by only keeping the iron in a crucible fill'd up with mere charcoal-dust, in a brisk fire, for the space of about a quarter of an hour.

* M. Muschenbroeck, counterpoising a prism of iron of three pound weight in a nice pair of scales, which would even turn with $\frac{1}{10}$ of a grain; and afterwards heating the prism red-hot, found that it still weigh'd exactly three pound: whence he concludes, that it had gain'd in weight from the fire. For the experiment being made in open air; and heat being always found to dilate iron; 'tis evident the specific gravity of the metal must have been diminished by such dilatation: which must have been perceived by the scales, unless some new weight had been added to it from another quarter. *De Materia Subtil.*

By

By an intimate solution of iron with water, it is that the famous preparation *Crocus Martis*, or saffron of iron, is made. In effect, all salts, both acid, alcalious, and intermediate, simple and compound, have a like effect on iron. And hence that elegant experiment of taking a large plate of iron, and applying to it, in one place, a drop of water; in another, a drop of vinegar; in another, a fixed salt; in another, volatile salt: for all these several salts will bring a rust on the metal; but a differently colour'd rust, according to the menstruum.

The *sixth character* is, that it neither resists the force of lead, nor anti-^{Iron render'd volatile either by lead or anti-mony.}mony, nor fixed salt; but being fused with them, readily dissipates into fume, or vitrifies.

The *seventh character* is, to be very sonorous, and elastic; tho' the ^{Its sound.}sound it yields is less sweet than that of copper.

The *eighth character* is, that of all bodies it is the only one attracted by ^{Attracted by the load-stone.}the load-stone*.

Iron is found in most parts of the globe; nay, even in all sorts of matter: particularly, all the parts of animals, both solids and fluids; as ^{Iron found in all places, and all bodies.}milk, urine, blood, fat, bones, flesh, &c. Out of any of these, iron is easily procured, by calcining them, and then drawing a load-stone, or the edge of a knife touch'd with a load-stone, lightly over the calx or ashes: for the iron particles are by this means drawn out of the ashes, and seen to adhere to the knife.

Again, all earths calcined, contain iron; as we see in clays, and potters earths; it being the iron alone that gives them their reddish colour, when burnt, or baked. The same is obvious of bricks, tiles, &c. which are

* But it must not here be forgotten, that iron itself may be brought to attract iron; or that it may become a magnet with respect to itself. Dr. Gilbert observ'd long ago, and Mr. Boyle confirms the observation, that iron-rods, as the bars of windows, by standing a long time in a perpendicular position, will grow magnetical: so that the bottom of the bar will attract the southern end of an animated needle, and repel the northern; but the upper end attract the northern, and repel the southern.

And hence, probably, the story current among the *Italian* naturalists, viz. that a large iron bar, supporting a cross of an hundred pound weight, on the top of the church of *Aramini*, was transmuted into an actual load-stone: a piece of which was preserv'd, among other rarities, in the repository of *Aldrovandus*.

Mr. Boyle adds, that having brought a large piece of *English* oker to a proper shape, and then made it red-hot, and let it cool again in an erect posture; it discovered a magnetical virtue; and would attract one end of a needle, and repel the other. *Mech. Prod. of Magnetism*. But whether this last case be not accountable for from the ferruginous matter wherewith that mineral is known to abound, even beyond some *iron-ores*, contain'd in the oker; will admit of some doubt.

The same author observes further, that the same virtue which a bar of iron acquires in a long course of time, merely by its position, may be soon imparted to it by

made

*Iron supposed
the basis of the
stone in the
bladder, &c.*

*And on what
grounds.*

*The weakness
thereof.*

made of a bluish, livid clay, and only become red in virtue of the iron particles mix'd with them*.

The learned Dr. Lister imagines he has discovered that iron is the basis of the stone in the bladder, and kidneys; and, consequently, that the more we eat of vegetable and animal substances containing such iron; or the more chalybeats, or iron medicines we take; the more matter is supplied for the generation of that distemper.

The foundation of this doctrine, which is now very current among the French, is that experiment above-mentioned of iron drawn out of the calx of human urine, or milk, or blood, or bones, or the stones themselves extracted from animals. But tho' thus much be allow'd true; yet still it may be doubted whether it be iron that generates the calculus. For when iron has contracted a rust, it is scarce attracted by the load-stone at all: so that it is a little presumptuous to argue thus: "All vegetable, and animal matter afford a calx which is attracted by the load-stone; consequently, the iron we take, furnishes the matter of the stone." Since iron itself, if corrupted by a salt or acid, or even by heat, does not act on the magnet. That excellent author, therefore, has carried the point a little too far: And accordingly, all he has wrote, on this principle, about spaw-waters, and chalybeat medicines, must be look'd on as very precarious, and hypothetical at best.

Separating of Iron.

*Iron, how found,
and separated.*

*By calcination,
and fusion.*

Iron is rarely found under its own form; but most commonly in black or brown gleans; from which it is never separated by mere fire alone; but some other menstruum is necessarily used, to absorb the sulphurous part. For this reason, the best way is to calcine the mineral glebe, by stratifying it with coals; and then to fuse, or melt the calx down by a violent fire. By this means, the metal is brought out fluid like water, and

* Iron-mines are common in most countries of Europe; Norway, Poland, Germany, France, England, &c. abound with them: only America, which is so plentiful of gold and silver mines, has none of iron: and, accordingly, the natives prefer a metal of so much use, infinitely beyond their own treasures. In some mines in Silesia, M. Stahl observes, they find grains of iron, already malleable. Mr. Boyle adds, that one of the best sorts of Swedish iron is found in form of a mud, at the bottom of lakes, and other stagnant waters.

Its common glebe, or marcassite, bears a near resemblance to the load-stone: as, in effect, that stone always yields true iron. Sometimes it is in pieces as big as the fist; and sometimes only in a sand.

Again, in some places, it is in the very surface of the earth, scarce an inch or two deep; but 'tis more common to have it at a depth of four, five, or six feet.

The forest of Dean, in Gloucestershire, is particularly rich in iron-ore; which it yields of divers colours, weight, &c. The best is that of a bluish colour, heavy, and full of shining specks, like grains of silver: but this, tho' it yields the greatest quantity of iron; yet, being melted alone, the metal is too short and brittle. To remedy this, they mix it with the cinder, or remains of old ore melted down long ago; which gives it that excellent temper and toughness for which this iron is so much prefer'd to any other. *Philos. Trans.* N^o 137.

receiv'd in moulds of different forms, according to the works it is intended for *.

Iron [*Mars*] is one of the noblest remedies all medicine affords; of more efficacy, in chronical cases, than all animal and vegetable matters put together. 'Tis greatly strengthening, and aperitive, or astringent, or styptic, as 'tis differently prepared †.

* In the iron-works at *Milbrop* in *Lancashire*, they use turf along with the charcoal, which makes the iron better than the coal alone. Beside, to the calx thus produced, they add about $\frac{1}{8}$ of the quantity of lime-stone unburnt, to make it melt more freely and cast the cinder, which they take off before they let the metal run. *Philos. Transact.* N° 199.

† The composition of iron we have already touch'd on in the notes, p. 66. But there remain some things on that head yet behind. *Van Helmont's* son, it seems, had a method of making iron with mud, and sulphur: The secret, *Becher* could never get out of him; but chance threw him on another, which he thus describes: Take clay, form it into little balls with linseed-oil, and lay them in a retort; urge them with a violent fire; and, after distillation, there will remain blackish globules, which, when ground and wash'd, will be a heavy matter, which the load-stone attracts. *M. Herman*, professor at *Erfort*,

accidentally made iron by the falling of some clay, wherewith a hole in a retort was stopp'd, upon the *caput mortuum* of some alum and sea-salt, which he was drawing the spirit from. Lastly, *Siball*, going to prepare some volatile spirit of vitriol; by mistake took a mass of alum, and common salt, instead of vitriol. The effect was, that, after the operation, he found a blackish matter; which, when wash'd, appearing to be very heavy, he presented the load-stone to it, but in vain: yet, after exposing it to a large burning-glass, he found it was become real iron, and readily flew to the magnet. He adds, that some of the mass which he took at first, gave no signs of iron, tho' long exposed to the burning-glass; and even, that tho' he poured a vitriolic spirit thereon, yet no vitriol was produced: which is a strong presumption that there was no iron in it then; for a martial earth, with the addition of a vitriolic spirit, never fails to afford vitriol. *Nouv. Cours de Chym.*



T I N.

Tin.

THE first character of tin is, that it is the lightest of all metals; tho' the heaviest of all bodies, except metals.

Its weight.

There are divers kinds of tin, which are each accounted the better as they are heavier; but of all others, that call'd *block-tin* is the most valued.

Softness.

The second character is, to be very soft; more so, than any other metal, except lead.

Volatility.

'Tis also greatly ductile, and very little elastic; less than any other metal, except pure gold, and silver.

The third character is, that of all metals, it is the least fix'd in the fire, and affords the greatest quantity of sulphurous fumes; and, consequently, loses most weight in the fire.

We have made divers experiments to this effect; the result of which puts the common observation of almost all the alchemists past doubt; viz. that tin will emit fumes even by the most gentle fire. The fume thus emitted, is the mere sulphur of the metal; accordingly, the more the sulphur is consumed, the lighter still it grows.

Fusibility.

The fourth character is, to be fusible by any the most gentle fire; and that long before ignition: tho' the purer the metal, the more difficultly it fuses. Add, that when urged even by an easy fire, it shines exceedingly; but this splendor is succeeded by a poisonous, sulphureous steam, very destructive to the lungs; as those who are employ'd in melting tin, find to their cost; it usually giving them a pale, ghastly complexion, and throwing them into a phthisis.

The evaporation being over, there is left a crust, or calx, called *calx of tin*; which being exposed to a very violent fire, becomes volatile, and flies entirely off*.

Miscibility with other metals.

The fifth property is, that it easily, and intimately mixes with other metals, as gold, silver, &c. and that it diminishes their ductility†, and gives them a degree of brittleness: whence, again, it is evident, it contains a great deal of sulphur.

If this sulphur could be perfectly purged out of tin, 'tis likely it would be found no other than silver: for as it is, the two metals have several properties in common. Thus, when dissolved in strong acids, tin grows

* Yet tin, thus calcined, and even volatilized, is again reducible into its metallic form. Thus Mr. Boyle: Tho' tin, in our reverberatory furnace, be usually only brought to a calx, which is reputed very fix'd; yet in those intense fires, an acquaintance of mine uses in his tin-works, quantities of this calx are carried up to a considerable height, where it gathers

into whitish masses; which, by a skilful reduction, yields great quantities of good malleable metal, rather finer than the ordinary tin. *Mechan. Orig. and Prod. of Volatil. &c.*

† Yet iron must be here excepted; that metal being render'd more malleable by a mixture of tin. *Novv. Cours de Chymie.*

bitter,

bitter, as well as silver; and when it is fused along with silver, it adheres so obstinately thereto, that there is scarce any separating them. Add, that under such circumstances it resists lead, almost as much as the silver does. And hence many account it an impure species of that metal*.

In effect, we have instances of silver's being actually made of tin; but not pure silver: Beside, that it has been made a capital crime to sell such silver; which has discouraged people from improving on the method †.

The sixth property is, that acids do not dissolve it without much difficulty, especially the more powerful ones. *Hardly dissoluble in acids.*

The reason hereof is apparently its abounding in sulphur; which acids, we know, do not touch. Add, that it dissolves in *Aqua regia*, scarcely in *Aqua fortis*; which is a circumstance remarkable enough, considering the near alliance it has with silver.

Again, the weaker the acid *menstruum* is, the sooner, and the easier it works its end; and the stronger, the more slowly: thus, four apples, and other unripe fruits, by being boil'd in tin-vessels, will grow sweetish; *Especially the more powerful ones.*

* It may admit of some doubt, whether tin bears these resemblances to silver, in virtue of its being tin, or only in virtue of the particles of silver mixed therewith. 'Tis certain, more of these resemblances, and those in a greater degree, are found in some species of tin than others. Mr. Boyle mentions a gentleman, who having procured a good quantity of the nobler metals from some tin-ore long digested in lixiviate liquors, desired Mr. Boyle to purchase him a large quantity thereof; in full expectation of raising an estate. But, says Mr. Boyle, after his first stock of ore was spent; the next that he procured, tho' managed with the same care as the former, proved wholly unprofitable. *Useful of Exper. Philos.*

The same author relates, that having dissolved some block-tin, (for so the workmen call that which is pure and unwrought) in a particular *menstruum* which kept it suspended; and having afterwards evaporated the solution, and set it to shoot; he found, to his surprise, that the crystals it afforded were not at all like its own kind of vitriol, but broad, flat, and thin, like those of silver: upon examining them further by the tongue, they had nothing of the taste of calx of tin made in spirit of vinegar; but that excessive bitterness we meet withal in the crystals of silver made with *Aqua fortis*. He adds, that finding this further resemblance betwixt the salts of those two metals, that both

of them presently tinged the nails and skin with a black that would not easily wash off; he should have suspected that the *menstruum* had exalted the metal into an affinity with silver; had he not afterwards prosecuted the same trial with the same *menstruum*, and another parcel of block-tin; and found, that tho' this metal was bought at the same place, and very soon after the other, yet the former success was owing to his having lighted of a lump of tin that was of a peculiar nature. *Useful of Exper. Philos.*

† Some authors speak much of the analogy between tin and lead; and will have tin to be lead, only under a less degree of cohesion: but if there be some circumstances wherein they correspond, they differ in others. Lead, for instance, is easily reduced to a calx; and tin more easily still: but the calx of lead readily melts, and runs into a brownish glass; whereas tin does not fuse and vitrify without much difficulty. Tin and lead do readily mix and unite with each other by a gentle fire; but, if the heat be intense, there arises a colluctation between them; the effect of which is, that both fall into a calx; and that the lead becomes exceeding difficult, afterwards, to fuse, and vitrify. Add, that tin is easy to be revived; but lead, not without the utmost difficulty: nor is the restoration any thing compleat; or the new body in all respects like the old one.

but the strongest and hardest acids, boil'd in the same vessels, make no solution at all.

Without calcination.

Tin, freed, by calcination, of its sulphur, dissolves readily enough, in all acids; and is reducible thereby into vitriolic crystals, which afford a noble remedy against diseases of the nervous kind.

Yet is it but little known and used in medicine; by reason of the difficulty of dissolving it; for it is to be first thoroughly calcined e'er a solution be attempted. The calcination requires a continual fire for three days; after which the calx is dissoluble in common vinegar. This is that excellent remedy of *Angelo Sala*, against the epilepsy and hysteric affections; in which it is not a less certain cure, than the bark in agues, or opium in want of rest.

Its sound.

The seventh character is to be very little sonorous; least of any metal, except lead; and yet, when mix'd with other sounding bodies, to augment their sound: as is evident from the share it has in the composition of bell-metal.

Add, that tho' it be but little elastic in it self; yet when mix'd with other elastic bodies, it wonderfully encreases their elasticity*.

Where tin is found.

Tin is principally found in *Cornwall* and *Devonshire*, provinces of *England*, from whence all the rest of *Europe* is supplied with this metal. 'Tis so much the peculiar produce of this country, that *Cambden* supposes it to have given the denomination *Britain* to the island. In the *Syrian* and *Chaldee* tin is call'd *bragmanac*, q. d. *Jupiter's* kingdom; the primitive whereof is *Bratman* or *Britman*, whence our *Britain*.

In what form.

Its glebe, or ore, is a heavy spongy stone; resembling a stone gnaw'd, or prey'd on by sulphur, or a bone half calcined.

How separated and purified.

These stones being broke and powder'd, undergo a lotion by water; by which means all the light earthy part is wash'd away, and the tin left at the bottom.

The matter thus separated, is next fused in a violent fire, by which means a deal of scoria is emitted, and the rest left pure tin. Which, if by any further process, it be purg'd of all its earthy, and fatty parts, approaches very near to the nature of silver †.

* A body, Mr. Boyle observes, by being associated with another, may have new properties and uses, and some of 'em quite different from what it had alone; i. e. two, or more materials, being conjoined, may be qualified into a third, by virtue of fresh properties thence accruing to the composition. As tin is flexible, and yields but a dead sound, who would dream that one considerable use of it should be to make a less yielding and better sounding metal, more strong and sonorous? yet bell-metal is principally compos'd of tin and copper. *Useful. of Exper. Philos.*

† The stones from which tin is wrought, Dr. Merret tells us, are usually found betwixt two walls of iron-colour'd rocks, of little or no affinity with the tin; in a vein or lead, as the workmen call it, betwixt 4 and 18 inches broad: tho' instead of stones they sometimes also find it mix'd with a small gravelly earth, generally of a red colour, but sometimes white. From this earth, the tin is easily separated by bare washing; which is call'd *pryan tin*, and is scarce half the value of the former.

In

Corollaries concerning the common nature and principles of Metals.

WE have now gone thro' the first class of fossils, viz. *Metals*, in all its branches; and what we have here done, may serve as a specimen in what manner physical things are to be defin'd, and explain'd: not by supposing any previous hypothesis, and deducing their nature therefrom; but by laying down their several apparent properties. From which we now proceed to draw some corollaries, which may furnish a general doctrine, or theory thereof.

COROLL. I.

That which distinguishes metals from all other bodies, as well as from each other, is their *heaviness*; for every metal is found to have its peculiar weight, which no art is able to imitate; and which depends, as *Helmont* ^{Weight the essential character of a metal.} and the chemists express it, on the *anattick* homogeneity of the parts.

Now, the later philosophers have proved, that all corporeal magnitude has just so much reality in it, as weight: and therefore, if you have found the heaviness of any metal, you have at the same time found its corporeity. Sir *Is. Newton*, treating of gravity, and *Huygens* of the pendulum, shew that weight and reality are correspondent.

COROLL. II.

Metals appear to be simple; and yet are really compounds: their component principles, according to the antients, are *sulphur* and *mercury*; to ^{Metals, compound bodies.}

In the tin ore, is frequently found a hard glittering sulphurous substance, call'd *mundic*, or *maxy*, which is commonly suppos'd to feed the metal; yet where the mundic abounds, they rarely find much tin. This mundic is to be carefully separated; for if there be the least of it left, in melting the tin, it makes it brittle, and cruddy, and diminishes much of its ductility.

There also occurs a sort of spar, of a shining whitish substance, soft and fattish at first, but soon after growing somewhat harder: it seldom grows, but only sticks to the metal. Some of the miners account this the mother, or nourisher of the metal. The best ore is that in sparks, and next to this, that which has bright spar in it.

The ore being dug, they break the greater stones, and thus carry it to the stamping or knocking mill, where it is pounded with large lifters headed with iron, 30, or 40 pound a-piece; and thus reduced into a small sand, to be wash'd out by a stream of water, discharg'd into it from a cock, thro' a brass grate holed very thick,

into a *launder*, or trench dug in the floor; out of which the water escapes, carrying with it the parts not metalline, which they call the *causalty*, at bottom.

To clear away the *mundic*, they dry, or burn the ore, thus separated, in a kiln, upon iron plates; keeping the matter constantly stirring, that all the mundic may by degrees get uppermost, and so be burnt away; which they discover by the flames growing yellow, and the stench diminishing. Then they proceed to grind it again, very fine, in a *crazing* mill: after which they wash it; then dry it a little; and at last carry it, thus prepar'd, to the furnace, which they call a *blowing* house; and there melt and cast it.

When it runs out of the furnace, there swims on it a *drofs* or scum like that of iron; which being melted down with fresh ore, runs into metal.

The causalty they throw in heaps upon banks, which, in six or seven years, they fetch over again. *Philos. Transact.* N^o. 69. p. 2096. and N^o 138. p. 948.

which some of the moderns have added *salt*. But, 'tis certain, salt is no proper constituent part or ingredient of metals; but rather something external adhering to 'em, and which makes no part of their metalline composition *.

Their principles. All metals then consist of two kind of parts, or principles, viz. *mercury* as the basis or matter; and *sulphur* as the binder or cement: the first, the substratum, or metalline matter; the second, that which renders it fix'd, and malleable.

Mercury. This *mercury*, it is to be noted, is the same with our quick-silver, only more defecate and clear of any of those heterogeneous matters, wherewith the common quick-silver is always mix'd: as to the *sulphur*, it is not the vulgar fossil sulphur, whereof we shall treat in its place; but a peculiar sort of matter, specifically denominated *sulphur of metals*, and contended by some of our latest, and best chemists, particularly Monf. *Homburg*, to be light or fire †. This being united with the mercury, fixes it; and according to the different degrees of its union, and coherence therewith, produces different metals.

This doctrine of the composition of metals, is confirm'd by an experiment of Mr. *Boyle*, who after having retain'd mercury a long time in a moderate fire, took a piece of gold out of it, which, it was apparent, was not in the mercury before it was expos'd to the fire.

Monf. *Homburg* has an experiment to the same effect; from which he deduces that gold consists of a sulphurous or igneous part; and a heavy, mercurial part fix'd thereby ||: and that by only taking away the

* "In the analysis of metals, we meet with mercury, a sulphurous matter, an earthy matter, and in some a saline matter". *Homburg Mem. l' Acad. An. 1702.* but this is chiefly to be understood of the imperfect metals; or of perfect ones not in their utmost purity; tho' the burning glass, we have already observ'd, separates a vitriifiable earth, even from the most perfect of all.

† This we shall have occasion to speak of more largely in the chapter of fire.

|| In an elegant memoir, *du souffre principe*, that ingenious and experienc'd author shews how a real malleable gold may be made of mercury, by only keeping it a long time expos'd to the fire, so as it may receive and retain a sufficient quantity of the matter thereof, to fix its slippery, volatile globules together, and make 'em sustain the fire, &c. In a second memoir, *du mercure principe*, he teaches to destroy both the gold and mercury, by applying it in the focus of a large burning glass; by the

vehement action whereof, the pores of the mercurial globules are so enlarg'd, and broke into each other, that unable, any longer to retain the fire lodg'd therein, it escapes; taking the greatest part of the mercury along with it; and only leaving a little light terrene matter behind.

The better to conceive, how mercury, when become a metal, should thus be destroy'd, by the penetration of the sun's rays, which are the same matter of light, that by a former penetration had convert'd the same mercury into a perfect metal; he shews that a perfect metal is pure mercury whose globules have been gradually pierc'd on all sides by the matter of light or fire; that the holes, or perforations made thereby, are all entirely fill'd with that matter; that these holes are so small, that the light introduc'd within 'em, sticks there by its natural gluten; that the extremes of the perforation of a mercurial globule being contiguous to the extremes of the like perforations of several other globules,

the sulphurous, or fiery part, the gold is reconverted into a running mercury*.

There are two ways of effecting this, viz. either by the revivifying salts of vegetables, or by mercury. *Metals reducible into their original mercury.*

That by mercury, M. *Homborg* assures us, is very easy; for that mercury, being purg'd of all heterogeneous matters, becomes a liquor, or menstruum that dissolves gold, by attracting, and melting the sulphur which fix'd the parts of the gold.

The like is done by those salts, which, from their effect, are denominated *revivifying*, viz. by their penetrating the metals, absorbing the fix'd parts, and, as it were, resuscitating the metals into their principles.

And hence all the books of the alchemists, are full of saline menstrua which act on gold in such manner as to fetch out its *soul*, i. e. our sulphur; leaving the *body*, i. e. that mercury of metals, behind 'em.

If it be ask'd why gold, if it only consist of the above mention'd principles, should be heavier than mercury? the answer is, that the particles of fire or light, which Mr. *Boyle*, and Mons. *Homborg* demonstrate to be heavy, coming to insinuate themselves into the pores of the mercury, and there fixing; increase its specific gravity. And no wonder: since the same is found to obtain even in calcin'd lead, as is known to all who have seen *minium* made.

globules, bind 'em together, by means of the colour of gold: and hence also the those parts of the matter of light found at great weight of gold; the particles of light such extremes of perforations; and that by entering the substance of the mercury, such means the whole mass of mercury becomes bound together. Now, notwithstanding this new union, the mercury and adding their own weight thereto, without augmenting the bulk. *Mem. de l'Acad. R. An. 1709.*

The great quantity of light imbib'd by the mercury, in making gold, possessing, as it were, the whole surface of the globules, effaces their native whiteness, and tinges 'em with its own yellow; whence

* Silver, according to the same author, differs from gold, in nothing but this, that the globules of its mercury are not so much penetrated, nor so thoroughly saturated with the sulphurous principle, or fire; a less quantity of which being lodg'd in the pores of silver, than of gold, leaves it short in point of gravity, &c. and does not discolour it.

Accordingly, proceeding on this supposition, he actually found that he could produce gold, by introducing a large quantity of fire, or of the rays of light, into silver. And hence it appears, that gold should be longer in forming than silver; and that all gold was first silver. *Memoir. de l'Acad. An. 1709.*

COROLL. III.

What blind
common mercury
from being gold.

All metals must first be mercury e'er they be gold; and the thing super-added to common mercury, whereby it is prevented from becoming gold, is a sharp, volatile body; which when heated becomes corrosive, and emits fumes; which are the properties of the fossil sulphur †.

This doctrine has been sufficiently laugh'd at, and exploded by many philosophers; but 'tis from their ignorance of the nature of metals.

In effect, what is here advanc'd, is the result of a world of experiments; nor does it appear, in any respect, inconsistent with reason: it must be admitted, then, as incontestable, that mercury is the matter of all metals; that as this is more or less pure, the metal is more or less ponderous; that there is no proof of any reality so clear and strong, as what is fetch'd from weight; and that the specific nature of a metal is known thereby. In effect, 'tis our opinion, that if any metal, or other body could be found, that only differ'd from gold in its wanting weight; it were impossible, while under that defect, ever to make gold of it; and, on the contrary, if a body could be had as heavy as gold; all the other properties of that precious metal, *v. g.* colour, fixity, ductility, &c. might easily be added.

Silver with all
the characters of
gold except
weight.

To say no more, I can shew silver that has most of the criterions of gold, excepting weight; being absolutely fix'd in the fire, and almost fix'd in antimony; and I can give it the colour of gold: and yet 'tis still, and will be, silver. But shew me silver as heavy as gold, and I will undertake to convert it into gold.

Hence the more knowing among the alchemists maintain, that "if you would convert, *e. g.* a piece of tin into gold, you must first carry it thro' all the intermediate weights of the other metals, *i. e.* it must first be the weight of iron, then of copper, then silver, then mercury, and at last gold.

Dogmata of the
alchemists.

They add, "that the primary matter of gold is mercury, which, say they, is gold at heart; as coming nearest to gold in the point of specific gravity: only there is a corrosive body, or sulphur, adhering to it, which if it were separated, you would have silver; or if it were only inverted, gold. On this principle, whoever would make gold out of any other foreign matter, must remember, that the more his matter differs from mercury in weight, &c. the less gold it will make; that if quicksilver could be reduced to the simplicity, and purity of gold, it would be gold; that the matter which coagulates, or fixes this mercury into gold, &c. is a very subtil sulphur; and that as we see, that quick-silver being held over the fumes of lead, is readily fix'd, it appears that a very little fixing matter suffices; that if mercury, coagulated by sulphur, have any impurities therein, it becomes lighter, and less perfect than quick-silver it self; that in the purification of mercury, to its highest degree, consists the making of gold;

* See the chapter of sulphurs.

"that nature, in some cases, is able to atchieve this of herself; that in other cases, where she is unable to do this, there arises a less noble metal; and that if the sulphur be not strictly homogeneous, there will arise a still more imperfect metal." Such, now, is that abstruse, formidable doctrine of the alchemists; so undeservedly exclaimed against by the other philosophers.

COROLL. IV.

Metals, therefore, appear transmutable into one another. For if mercury be the common matter of all metals; and if all the difference lie in the fixing matter, which, as 'tis more or less subtle and pure, constitutes this or that metal; 'tis no way improbable they should be converted, by a purer fixing sulphur's taking place of a corrosive one, into a more perfect metal.

Transmutation of metals not impossible.

COROLL. V.

The purest metals result of the purest and most defecate mercury, join'd with the subtilest sulphur; hence mercury of gold is heavier than common mercury, which has always some impure part that is lighter than gold: and could that be taken away, and the fixing spirit be added, it would become gold.

Composition of the perfect metals.

COROLL. VI.

The imperfect metals consist of impure mercury, and imperfect sulphur; each containing some other variable heterogeneous matter in it: thus tin exposed to the fire, emits a fume which whitens copper; after which, it exhales a pure sulphur.

Of the imperfect.

The reality of such a third matter is evin'd hence, that all these baser metals are resolvable, not only into mercury, and sulphur, but also into scoria, or fordes, which are lighter and more earthy than either of the other, and accordingly swim therein.

If this matter can either be changed, or be perfectly purg'd away, any one metal were convertible into any other; the most impure, into the purest. Thus, *Centivoglio: Nature sublimes mercury in the earth, by heat; which sublimation is repeated again and again, till every thing impure and heterogeneous be carried away, and what is pure left at the bottom. When what is thus left, is quite pure, it is gold.* Agreeable to this, is that of *Monf. Homberg: Separate the pure, from the impure, over and over; and you will obtain what you desire. This is just the case of nature: if she can carry the separation to its pitch, gold is produc'd; otherwise, some baser metal.*

This fixing sulphur is held by some alchemists an universal medicine in all cases where the innate warmth is wanting, and the native force decay'd: but in acute cases, it is quite the contrary, and certainly destroys.

in *Centivoglio*, an alchemist enquires of sulphur, which appear'd to him in his sleep; *Is the universal medicine in thee? Yes, replies sulphur; provided you apply me where the vital heat and force of fire is wanting: but where there is too much of that heat and force in the body, I destroy.* Hence *Helmont* was induc'd to believe sulphur to be the grand elixir; but *Centivoglio*, and *Van Suelten*, a disciple of *Paracelsus*, more discreetly limit the use of this universal medicine, to chronical cases, and particularly hydropical and lunatic ones.

Thus much for *metals*: and by this time, what with our own experiments, and what with the sure observations of the best, and most intelligent authors, we have got a pretty adequate notion thereof.

We have added what relates to the art of *transmuting*; that such as have the curiosity to make any experiments in this kind, may have some laws, marks, or aims, whereby they may securely direct themselves; and that such as might be in danger of being imposed on by fraudulent alchemists, may be furnished with means to discover the deceit. The weight, once more, is the immutable judge; and, in all cases of doubt, appeal to the balance.

This doctrine of transmutation, may be of especial service to the novices in chemistry; who, by I know not what fatality, have an almost universal itch after the philosopher's stone, and the making of gold. Instances of vain people, reduced from plentiful fortunes to the lowest beggary, by their own conceits, or the empty pretensions of designing alchemists, fall under most peoples observation.



Second Class of Fossils.

SALTS.

After metals, the next bodies in order of simplicity, are *salts*; the ^{Salt.} definition whereof is as follows:

Salt is a fossil body, fusible by fire, and congelable again, in the cold, into Defined. brittle glebes or crystals; soluble withal in water, so as to disappear therein, never malleable; and having something in it which to the organ of taste affords a sensation of acrimony or sharpness.

Such is the precise idea of a *salt*; which agrees to all salts whatever; and by which a salt is distinguished from all other fossil, vegetable, and mineral bodies.

The properties peculiar to any species of salts, are not taken into this definition: thus, we don't say, *that it excites thirst*, or the like; since the salt in sugar is sweet, and has no such effect.

Fossil-salts are of two kinds; *native* or *simple*, and *compound*. We have here only to do with the *native* ones: which are,

1°, *Sea-salt, sal marinus*, thus called because extracted from sea-water: ^{Common salt} it is the most universal of the whole tribe; being found in every part of the ocean, and in every gulph, &c. communicating therewith: witness the *saline* taste in all sea-water; but in lakes, or other stagnant waters, it is scarce found at all*.

'Tis this saltiness of the ocean that prevents its growing fetid, and putrefying by the heat of the sun; and yet, notwithstanding all its saltiness, the freshest fishes live, and grow therein. It is found in greatest abundance, where the sun's heat is the most intense; and the least in the coldest regions.

This

* For *sea-salt*, the greatest, and best part, is made along the coasts of *France*. There are two kinds of it; the one requiring the sun's rays to bring it to a consistence, call'd, from its brown colour, *bay-salt*; the other receiving its consistence from the heat of a fire, called *white-salt*: either the one or the other method is practised, according to the disposition of the coasts where 'tis made. If they rise in downs, or banks of sands, the salt is made by fire, in copper, or leaden vessels: if the bottom be clayey, the salt is crystallized wholly by the action of the sun. The method of proceeding in each, is as follows:

P

1°, For *bay-salt*. Low, marshy grounds, disposed by nature for the reception of the sea-waters when the tide swells, and provided with banks and sluices to retain the same; they call a *salt-marsh*. These salt-marshes, the bottoms whereof they ram with great care, are divided into square pits or basons, separated by little dikes; and into these basons, when the season is at hand, they let in the sea-water. The salt-season is from the middle of *May* to the end of *August*. The water is admitted to the height of about six inches; after having first let it rest, and warm two or three days in huge reservoirs, without the works, that it may come

come

This sea-water, being first percolated thro' a *Manica Hippocratis*, or straining-bag, is then boil'd, scum'd, and evaporated to the consistence of a brine or pickle; (which is proved by a new-laid egg's swimming therein,) in which state being left to settle, the salt sinks to the bottom in crystals.

Rock-salt.

2°, *Sal gemma*, popularly call'd *rock-salt*, is dug out of mountains, and cloven or slit into glebes or lumps.

The finest in all *Europe* is in a mountain of *Catalonia*, not far from the city *Barcelona*: but there is scarce any part of the earth without it; no part, at least, that has any mines at all. In *Poland*, *Russia*, &c. there are several whole mountains thereof*.

Thus

come in luke-warm. The water admitted; the sluices are shut, and the rest of the work left to wind and sun.

The surface of the water being struck, and agitated with the direct rays of that luminary; thickens, at first imperceptibly; and becomes at length cover'd over with a slight crust; which, continuing to harden, is wholly converted into salt. The water in this condition is so hot, that the hand can't be put in without scalding. When the salt has receiv'd its full coction, they break the crust with a pole; upon which it sinks to the bottom: whence, being dragg'd out again, they leave it in heaps about the pit, to compleat its drying; covering it over with straw, or rushes, to secure it from the rain.

Eight, ten, or at most fifteen days, having thus compleated the crystallization, they open the sluices, when the tide rises, for a fresh stock; and thus, alternately, while the season holds.

2°, *White sea-salt*. On the flat shores of *Normandy*, they gather a muddy sand, which the rising tide has impregnated with its waters for seven or eight days. This sand being removed into pits for the purpose, discharges itself, by degrees, of all its water; which filtrates thro' some straw, wherewith the bottom of the pit is fill'd; and trickles into vessels set on purpose to receive it.

This water they lade out into leaden boilers, with furnaces under them. As soon as it begins to boil, they take off the skin, which rises in great quantity; and in proportion, as it diminishes, throw in fresh water, which they continue to skim, as before. When it thickens, they keep

it continually stirring; and when the grain is form'd, take it off the fire.

This done, it is put in large oser-baskets; where it stands some time to purify, and drain itself of certain humidities that remain'd: when dry, it is laid on heaps, and thence carried to the magazines.

Note, They have also a method of refining *bay-salt* into *white-salt*, by boiling it in large flat-caldrons; which not only takes away a deal of its acrimony, and alters its colour, but is also found to increase the quantity.

* This salt appears to have been entirely unknown to the antients. *Pliny*, indeed, gives us some curious things about salts, which we should have been glad to have transcribed hither, could we believe them as true as they are pretty. Instead hereof, we shall content ourselves with what well-warranted relations we could get of those celebrated salt-mines of *Wilicza* in *Poland*; from whence the rest of *Europe* is supply'd in great measure with this salt.

The mines in the village *Wilice*, five leagues from *Cracow*, were first discovered in 1251; their depth, and capacity, are surprizing: within them is found a kind of subterraneous republic, which has its polity, laws, families, and even high-ways, and common carriers; horses, and other cattle being kept here to draw the salt to the mouth of the quarry, where it is raken up by engines. These horses, when once they are down, never see the light more; but the men take frequent occasions of breathing the village-air. When a traveller is arrived at the bottom of the strange abyfs, where so many people are interr'd alive, and where so many are even

This salt being dissolved in water well-seum'd, and set in a cool place, shoots into cubical or prismatical crystals, very smooth, polite, &c.

These two salts scarce differ in any thing but the place they are found in; unless, perhaps, in the degree of purity, and dryness; in which the latter exceeds. They have both the same effects on gold, which is not dissolvable by any other salt in nature, but these two. They have the same effects, too, in the making of spirit of salt, in fertilizing barren grounds, in seasoning, pickling, and other culinary uses; and their taste is the same.

In effect, there is no room to doubt but that they are really one and the same salt; and that sea-salt had its first rise from *sal gemma* dissolved at the time of the flood; and since that, by earthquakes, inundations, &c. which have laid parts of the earth under water.

These two are called *perfect salts*, and are of all others the most fixed, and immutable both in the fire and the human body: salt-petre, even the most refined, perishes, or is quite lost when swallowed down; and sal-ammoniac, borax, &c. shew no signs of themselves in the urine: but sea-salt, &c. may be always drawn from it; so that it must be allow'd an exceedingly simple body*.

The

even born, and have never stirr'd out; he is surprized with a long series of lofty vaults sustain'd by huge pilasters cut with the chissel; and which, being themselves rock-salt, appear, by the light of flambeaux, which are incessantly burning, as so many crystals, or gems of various colours, casting a lustre which the eye has much ado to bear.

The rocks of salt are hewn in form of huge cylinders; the workmen using hammers, and chissels, much as in our stone-quarries. As soon as the massive pieces are got out of the quarry; they break them into fragments fit to be thrown into the mill, where they are ground into a coarse farina, or flower.

Here are two kinds of *sal gemma*, the one harder, and more transparent, and which appears to be the more perfectly crystallized. This is the proper *sal gemma*, and is frequently cut like crystal, and form'd into toys, chaplets, little vases, &c. The other is less compact, and only fit for kitchen-uses. One of the chief wonders of the place is, that thro' these mountains of salt, and along the very middle of the mine, there runs a rivulet of fresh water, sufficient to supply the inhabitants.

In the salt-mines of the *Upper-Hungary*, and the mountains of *Cardonna* in *Catalonia*, the salt-stone is found of various colours, bay, white, red, blue, green, brilliant, &c.

* To the same species of salts, must, likewise, be refer'd that commonly made, and used in our own country; viz. the salt drawn from brackish springs; which, no doubt, either arises from the salt-water of the sea receiv'd up thro' certain subterraneous cavities, and deposited here; or from some mineral or gem salt, lodg'd in the *strata* of some of the mountains not far off, wash'd down by some rivulet or track of water, and gather'd here. The way of preparing it, is thus:

Near the spring is built a *saltern* or boiling-house, furnished with several huge, flat pans, with each its grate, and furnace. Into these the brine is convey'd by pipes; the fire kindled; and in two hours time the liquor begins to be ready to granulate, which is known by a thin skin rising at the top, which they skim off into brine-tubs. The sand, which the water yields pretty plentifully, is by the violence of the boiling cast to the sides, and corners of the boiler; where they lade it out into vessels for that purpose. Both this

Theory of CHEMISTRY.

3°, Is salt-petre, called also nitre *, and *sal nitri*, whose characters are, 1°, That its crystals are of a prismatic figure, with hexagonal bases. 2°, That it dissolves by fire more readily than any other salt; but with some difficulty by water or moist air. 3°, That it is the coldest of all salts, and affects the tongue much like ice; having a saltish savour withal. 4°, That it is the basis of *Aqua fortis*, and dissolves silver.

As to the origin of salt-petre, 'tis controverted among naturalists, whether it be a fossil or an animal salt; some holding it producible from the

sand, and the scum, contain salt, which they procure by a future operation.

The sand being removed, they shut up the vent-holes, and door, and let the fire go out; and in twelve hours time, the salt is precipitated to the bottom; where it grows hard; a liquor, call'd the *bittern*, remaining a-top; which being boil'd over again, yields more salt.

To make the salt precipitate more readily, they frequently use beef-suet, and wine-lees, of each an equal quantity; melting them together, and putting an ounce of the mixture on the end of the slice, and turning it round in the liquor, till all be spent: then, after two hours at most, opening the vent-holes, &c. and quickening the fire, they lade away the liquor; and find the salt lying at the bottom.

Lastly, taking it out, they put it into cribs or sepels like hay-racks; where, after eight hours draining, it is found a hard, granulated salt; yet it continues dripping a fortnight longer; and, unless it be frequently stirr'd, becomes rocky.

* As to that of the antients, 'tis disputed among naturalists, whether their *nitre, natrum*, were the same with our salt-petre. The account *Serapion* gives us of nitre, should make them very different; for he says it was dug out of mines like those of common salt. He adds, that their nitre was of four kinds, denominated from the countries whence it came; viz. *Armenian*, *Roman*, *African*, (call'd *Apbronitre*, and by *Auscenna*, *Baurach*) and *Egyptian*, which being the most famous, gave name to all the rest; itself being denominated from *Nitria*, a province in *Egypt*, where it was found in great abundance. He assures us, too, that their nitre was of divers colours, viz.

white, red, and livid; that some was spongy, others more compact, others transparent, others scaly, &c.

The learned *Schelhammer*, in an express treatise, *De nitro, tum veterum tum nostro*, sets the thing in a very different light: the antients, he observes, distinguished *νιτρον*, nitre; *αφρονιτρον*, *Apbronitre*; and *σπυμα νιτρον*, *spuma nitri*, or scum of nitre. He adds, that *Agricola*, and other authors, are mistaken when they say that there were antiently mines in *Lydia*, *Magnesia*, *Caria*, &c. out of which nitre was dug like stones out of a quarry. The nitre used by the antients was brought from several countries mentioned by *Pliny*, lib. xxxi. c. 10. A lake in *Macedonia*, whose waters were nitrous, furnished the greatest quantity, and the best; it was call'd *callustrium*, from a neighbouring cape in the gulph of *Thessalonica*; and was form'd like a crust on the surface of the water, during the dog-days. On the other hand, the waters of the lake *Ascanius* in *Bithynia*, and those of certain springs near *Chalcis*, were sweet, and potable toward the surface, yet nitrous at bottom. There was also nitre gathered on the ground near *Philippi* in *Thrace*; but it was little, and of no great value. The valleys of *Media* also furnished some.

The reader, who is curious to enter more minutely into this controversy, may consult the *Acta Erudit. Lips.* Ann. 1701. p. 361. Ann. 1709. p. 318. Ann. 1711. p. 214. The *Ephemer. Curios. Nat.* Dec. 1. Ann. 1. p. 290 & 403. Ann. 4 & 5. p. 285. Ann. 6 & 7. p. 170. Ann. 8. p. 270. Ann. 9 & 10. p. 270. Dec. 2. Ann. 3. p. 87. Ann. 4. p. 21. Ann. 7. p. 306. Ann. 9. p. 88. &c.

mere excrements of animals *. But this is not so just, as to say that it is produced from those excrements intermixed with the salts of vegetables, &c. which seems to constitute it rather an hermaphrodite, or salt of a middle kind, between fossil and animal †.

We have four sorts of salt-petre; two *native* or *fossil*; and two *factions*.

The *first native* salt-petre is brought from the *Levant*; where it is dug up from under ground, in mountains, &c. in form of a variously colour'd mineral glebe ‖.

The *second*, called *Natron*, or the *Egyptian* nitre, is of a more cineritious colour, and a bitterer taste; approaching nearer to the nature of a *sal-ammoniac*.

It is not produced from the plant *kali*, or salt-wort, as some have imagined; but from a huge lake in *Egypt*, on whose banks the camels, and other animals, lay their excrements; which by the inundations of the lake being drawn into the water, are supposed to afford the matter of this salt.

The water of this lake being scorched, and evaporated by the heat of the sun, gathers a pellicle or scum, which being dissolved, and crystallized, yields the salt **.

The

* M. Homberg observes, that all the salt-petre we now have, is either drawn from earths moisten'd, and manured with the excrements of animals; or from old walls, and the plaister of ruin'd buildings impregnated with the excrementitious effluvia of the animals that inhabited them. *Mem. de l'Academie*.

† Indeed, salt-petre may be made many ways. M. Lemely made it both of animal, and vegetable matters. Ludovicus observes, that the art of making a real nitre of the essential salts of certain plants join'd with a fixed salt, has been known long ago; oil of tartar *per deliquium*, pour'd on spirit of nitre, evaporated to a cuticle, and left to crystallize, does the business. *Nouv. Cours de Chymie*.

‖ This species of salt-petre, call'd *mineral salt-petre*, is found in several places in the kingdom of *Persia*, &c. particularly about *Agra*; in villages antiently populous, but now desert. 'Tis also found in some places about the river *Volga*.

The glebe or earth from which it is procured, is of three different kinds; black, yellow, and white: The method of procuring, is thus; two flat pits are dug, one of which they fill up with the mineral earth; turning water upon it for some

time, and then treading it with their feet into the consistence of a pap; and letting it stand two or three days for the water to imbibe, and extract all the salt. They then shift the water into another pit, where standing some time, it shoots, and crystallizes into salt-petre. To purify it, they boil it once or twice, as they would have it more or less pure.

** This salt-petre is furnish'd by the waters of a dead lake in the district of *Terrana* in *Egypt*, call'd the *nitrian waters*, exalted and concocted by the heat of the sun, much after the manner of our bay-salt. This is the *natrum* or *anatum* of the antients, which our druggists call *natron*.

Dr. Huntingdon, who was on the spot, observes that *natron* is commonly supposed to rise from the bottom of the lake, where, by the sun's heat, it is condensed, and harden'd into the form we see it: but his opinion is, that it is rather separated by the sun from the water. *Philos. Transact.* N^o

This salt agrees with our salt-petre in some properties, viz. in the pyramidal form of its crystals, &c. but differs from it in others, viz. its lixivious smell, fermenting with acids, &c. Dr. Leigh takes it to come nearer to the nature of a *sal-*

The first species of *facitious* salt-petre arises from a liquid matter or juice exuding out of old walls, and gathering into little white *floculi*; which, by being pounded, become salt-petre.

This matter proceeds primarily from the calx or lime of the walls; tho' it is found, that if the stones themselves be boil'd in water, and the water filtered and inspissated, salt-petre will be obtain'd.

The second is procured from the *faces* ††, and urine of animals: nay, all the very fleshy parts thereof, when putrified, afford this salt.

Sal ammoniac. The 4^o, is the ancient *sal-ammoniac*, or *sal Cyrenaic*, described by *Pliny*, and *Dioscorides*.

Its generation was in the earth, or rather, the sands, in those large inns, or *Caravanserai's*, where the companies of travellers, or pilgrims, flocking from all parts to the temple of *Jupiter Ammon*, used to lodge. The method of conveyance in those parts being on camels; and these beasts, when in *Cyrene*, the province wherein that celebrated temple stood, urining in the stables, or, say some, in the parched sands; of their urine, which is found remarkably strong, was generated a sort of salt, denominated, sometimes from the temple, *Ammoniac*; and sometimes, from the region, *Cyrenaic*.

This salt being now no longer found in those places, some authors suspect there never was any such thing; and that the antient, as well as the modern *sal-ammoniac*, was *facitious*.

But we are inclined to think there might be a native salt of this kind; and the rather, as the salt belched out in large streams, or rivulets, from mount *Aetna*, is of the same nature; and that the ordinary spuma or froth emitted out of that mountain, affords a pure salt, which answers to most of the properties of the *sal-ammoniac*.

The true reason why this salt is no longer found in its former place, is, that the fane of the antient idol is now out of date; and that there are no oracles to be consulted there.

Its characters are, 1^o, That it cools water. 2^o, That it turns *Aqua fortis* into *Aqua regia*, and dissolves gold. 3^o, That it remains fixed in a gentle fire, but sublimes by a large one. 4^o, That the taste it affords, is quicker than that of salt, and resembles that of urine.

Modern sal ammoniac.

The 5th salt, is the modern *sal ammoniac*, which some pretend to be native or fossil, and to trickle out of the ground in *Campania*, and other parts of *Italy*; as also about mount *Aetna*, in *Sicily*, in form of a liquor, which

ammoniac: which opinion is confirm'd by Dr. Lister, from a conjecture, that most of the salt-water of the lakes of *Egypt* must have passed thro' the bodies of those vast animals wherewith they are inhabited; as crocodiles, hippopotami: and consequently must have been render'd urinous: which is the character of *sal-ammoniac*.

†† This sort is chiefly made in *France*; particularly in the arsenal at *Paris*, where there is a corporation of salt-petre-makers appointed for the purpose. The materials are chiefly collected from old buildings, ruins, plaister, dove-houses, stables, privies, &c. The process is as follows:

They take, for instance, some old plaister, and put it in troughs, or vats; here they beat, and break it, and pour on it a lye made of new wood-ashes. This they repeat ten or twelve times, till it be saturated

which when filtrated, and inspissated, becomes *sal-ammoniac*. But 'tis certain, all the modern *sal ammoniac* is compound, and factitious; and consists of a fossil, vegetable, and animal salt combined together*.

The 6th salt is *borax*, which is a native, fossil salt, of a very extraordinary kind; of whose origin we have no well-warranted, and authentic account †.

It is very fusible by fire, and in cold coagulates again, and shoots into glebes of a prismatic figure. It is of a sweetish taste, promotes the fusion of metals by fire; and when sprinkled over them, serves to cement or folder them together.

It is principally used by goldsmiths, and other artificers to folder gold with other metals; in order to which, they apply a little borax powder on the gold, and melt it by a lamp; whence it is also called *Chryscolla*, q. d. glue of gold.

The 7th salt is *alum*, which, tho' no pure, simple, native salt, yet *Alum* has all the properties thereof; being dissolvable in water, acids, &c.

Alum is of divers kinds, *red*, *roman*, *citron*, *saccharine*, and *plumose*; tho' the last is not properly *alum*, but a sort of fossil salt, which remains

rated enough to sustain an egg: then they pour it into fresh vessels; where, in cooling, it shoots into little greyish crystals, intermixed with sea-salt. This done, they dissolve it again in a lye, wherein the sea-salt crystallizes first; and thus affords an opportunity of separating it from the salt-petre. They proceed to dissolve, and crystallize it again and again; skimming off the remains of the lye each time. When the salt is left pure, they melt it over a gentle fire; and thus pour it into vessels to keep.

* There is scarce any drug more common than *sal-ammoniac*; and yet we neither know whence it comes, nor how 'tis made. All that is certain, is, that it is brought from the *Levant*. The chemists all allow it a volatile, urinous salt, penetrated by an acid; and have divers ways of making the like: the common way is by putting one part of common salt to five of urine; to which some add half the quantity of soot. The whole being put in a vessel, they raise from it by sublimation a whitish, farinaceous, friable substance; which is what they call *sal-ammoniac*. But M. *Lemery* shows, that what is imported to us from abroad, must be made after a different manner. He even concludes, that it is made, as our common salt is, by mere lotion, and evaporation.

† *Pliny* speaks of borax at large, in his *Nat. History*, lib. xxxiii. c. 5. but his account is not perfectly consistent with modern experience. He divides borax into native, and factitious: The native, according to him, is a kind of muddy juice, running in gold, silver, and copper, and even lead-mines; which being congeal'd, and harden'd by the winter's cold, arrives at the consistence of a pumice. As to the artificial, he says, it is made by pouring water into the vein of a mine all the winter long, till June; and then leaving it to dry, and harden for three months: so that borax, according to this naturalist, should be no more than the mineral corrupted. He adds, that the borax becomes yellow, white, green, or black, according to the mine it is found in.

The moderns, likewise, admit of a native, and an artificial borax: The native is a mineral salt, not unlike *sal gemma*, dug out of the earth in divers parts, particularly in *Persia*. It is also found at the bottom of a torrent, running from the mountains of *Purbeth*, near the confines of *White-Tartary*.

The factitious is only the native purified, and refined, by dissolving it in water, filtrating and crystallizing.

fixed in the fire. The saccharine again is artificial; and therefore has no place among native alums*.

Alum dissolves in water; and what remains undissolved, at bottom, is a sort of calx, which dissolves readily enough in oil, or spirit of vitriol. And hence, there arises some doubt whether alum, as it leaves an earth or *caput mortuum* behind it, does properly belong to the class of salts.

Vague univer-
sal acid.

The 8th and last is a certain *vague-salt* or *acid*, diffused in all parts of the earth; which, when alone, is volatile; but when it has a body or subject to adhere to, becomes fixed.

The idea of this salt we are at a loss how to convey, otherwise than by its effects; it seems to come nearest the nature of spirit of sulphur *per campanam*; and is discovered in all sulphur, in all vitriol, in all alum, in all nitre, in all fossil coals, &c. This same acid is that pernicious fume or damp, found in mines, and cellars; the same is that smoke which flies from bituminous turf, &c.

This we call the *saline acid* †, and look on it as a vague, indeterminate principle, distributed thro' every part of the globe, both inside, and out. 'Tis this *acid* that dissolves iron, and copper in hot baths; this, that meeting with fossil or rock-oil, coagulates, and converts it into *sulphur*: this that, being received into the earthy part of alum, or the *lapis calcarinus*, converts it into alum: this, in fine, that, insinuating into the substance of iron, produces green vitriol; or into that of copper, blue vitriol, || &c.

Ele-

* England, Italy, and Flanders, are the countries where alum is principally produced. The English alum is made from a blueish, mineral stone, frequent in the hills in Yorkshire, and Lancashire. This stone they calcine on a hearth or kiln; then steep it successively in several pits of water: then boil it for about twenty-four hours: Lastly, letting it stand for about two hours; the impurities subside, and leave a pure liquor; which, removed into a Cooler, and some urine added to it, begins, in three or four days, to gather into a mass: which being taken out, wash'd, and melted over again, is fit for use.

In the alum-works at Civita Vecchia, the process, as described by M. Geoffroy, is somewhat different. The stone, which is of a ruddy hue, being calcined, they boil, and dissolve the calx in water; which imbibing the salt, i. e. the alum, separates it from the useless earth. Lastly, leaving the water thus impregnated with salt, to stand for some days, it crystallizes of it-

self, like tartar about a Bur, and makes what they call *rock-alum*.

At Solfatara, near Puzzuoli, is a considerable oval plain, the soil whereof is wholly saline; and so hot, that the hand cannot long bear it. From the surface hereof, in summer-time, there arises a sort of flower or saltish dust; which being swept up, and cast into pits of water at the bottom of the plain, the heat of the ground, without any other fire, evaporates the water, and leaves an alum behind.

† This coincides with the elementary salt, or saline principle, the basis of all fossil salts. See it further consider'd among the other elements, under the article *Operations*.

|| One of the principles into which sulphur is, by analysis, reducible, is an acid salt; which Sir I. Newton observes, "is no other than the oil of sulphur *per campanam*; and which abounding much in the bowels of the earth, and particularly in marcasites, unites itself to
" the

Elements or common principles of salts.

OF fossil salts, some are simple, i.e. not reducible into any principles or component parts; such are *salt-petre*, and *borax*.

The rest are all resolvable into an acid spirit, and an insipid earth*. Thus, e.g. if you take a quantity of sea-salt, and lay it open to the air in a shallow vessel of *Muscovy* glass; all that does not liquify, is earth: If it be in a place secure from dust, the salt thus liquified becomes brine; which being dried, and exposed again to the air, and this repeated over and over, the whole acid spirit will at length be evaporated, and nothing left behind, but the insipid earth, which readily absorbs any fresh acids, &c. poured on it, and re-commences salt†. Salt, therefore, contains a little share of earth to fix and retain its volatile acid‡.

"the other ingredients of the marcasite; which are bitumen, iron, and earth; and with them compounds alum, vitriol, and sulphur: with the earth alone it compounds alum; with the earth and metal, vitriol; and with the earth, and bitumen, sulphur. *Optic.*"

* "When metals corroded with a little acid, turn into rust, which is an earth tasteless, and indissoluble in water; and this earth imbibed with more acid, becomes a metallic salt: and when some stones, as spar of lead dissolved in proper menstruums, become salts: Do not these things shew, that salts are dry earth, and watery acid, united by attraction; and that the earth will not become a salt, without so much acid as makes it dissoluble in water." *Newton. Optic. p. 361.*

† Yet M. *Homburg* insists, that there is always a little fixed salt remaining with the earth. *Mem. de l'Acad. 1702.*

|| Fossil salts left to shoot or crystallize, assume certain figures, which are usually attributed to them as their proper figures; tho' sometimes supposed to be the figures of the acids of those same salts. These figures are, in sea-salt, cubes; in sal-gem, parallelepipeds; in salt-petre, a sort of needle form; in alum, triangles, with the points blunted; in borax, flattened ovals; in sal-ammoniac, branchy needles, &c. Yet, upon examining the configuration of these salts, it will appear, that such figures do by no means belong either to the salts, or the acids, procurable from them; but rather to the alcalies whereby they are dissolved, and which serve them as bases. And hence, the same acid assumes different figures, according to the different alcalies it is saturated withal, e'er it crystallize. Thus, spirit of nitre, after dissolving copper, shoots into hexagons; after iron, into irregular squares; after silver, into triangular, dented plates, &c. *Homburg. Mem. de l'Acad. R. An. 1702.*

Q

Third

Third Class of Fossils.

STONES.

Stones defin'd.

THe next bodies, in order of simplicity, are *stones*. Now, A stone is a fossil body, twice as heavy as water; friable, and therefore not malleable, but falling under the hammer into powder; not dissoluble in water; nor scarce fusible by fire, but rather reducible into ashes.

Stones, therefore, are distinguish'd from metals in their being friable, which is a property that even diamonds themselves are not without; notwithstanding what the antients imagined of goats blood being necessary to make 'em so: and they are distinguish'd from salts, in not dissolving in water: as, from sulphurs, in not fusing by fire.

Divisions of stones.

Stones are popularly divided into vulgar, and pretious; or, which amounts to the same, into opaque, and transparent*.

PRECIOUS STONES.

Precious.

A Precious stone, call'd also gem, and jewel, is that which is durable, transparent, and of a beautiful colour, or water.

Of these, there are three kinds. First, such as are entirely transparent; which again, are either colourless, as the diamond; or colour'd, as the emerald, &c. The 2d, brilliant, or shining, as the Bohemian granate: the 3d, Semi-transparent, as *Oculus cati*, opal, &c.

The division of colour'd gems, may be subdivided into such as have but one colour throughout; as the ruby: or such as have several colours, as the amethyst†.

Among

* Some other naturalists make more minute divisions: the curious and learned bishop Wilkins, for instance, considering stones in respect of their value, makes an intermediate kind, between vulgar, and precious, viz. middle priz'd.

The accurate Dr. Woodward chusing to consider stones, not in respect of value, which is arbitrary and extrinsic, but of something that belongs to themselves, divides them into those found in larger masses, and those in lesser masses; which latter he subdivides into such as do not exceed marble in hardness, and such as do exceed it. These last make the class of precious stones in the other divisions.

† Bishop Wilkins divides precious stones into more and less transparent. The less transparent he distinguishes by their colours: into red, as the sardius and cornelian; pale, fleshy colour, like that of a man's nail, as the onyx; blueish, as the turquois; pale purple, as the chalcedony; and those of various colours, as opal and cat's eye.

The more transparent he distinguishes into such as are colourless, as the diamond and white saphir; and colour'd, which are either red, as the ruby, carbuncle, and granate; yellow, as the chrysolite, and topaz; green, as the emerald, smaragd, and beryl; blueish, as the saphir; and purple or violaceous, as the amethyst and hyacinth.

Dr.

Among precious stones, the first place is due to the diamond, or adamant, as the hardest, and most transparent of all others; and it may be added, the most simple, and homogeneous, too: so that the diamond seems to be that among stones, which gold is among metals. The pseudo-diamond is sufficiently pellucid, compact, and weighty; but not so hard, nor capable of the lustre and polish of the true diamond.

The variety of stones seems to result from no other than the admixture of other heterogeneous, perhaps metalline particles, with the simple crystalline base†. Thus, according to the several circumstances, kinds, quantities of the superadded metalline impurity, arise several kinds of stones, of several properties, colours, weights, &c. The crystal itself is absolutely pure, pellucid, colourless, &c. And that it produces stones which are otherwise, is apparently owing to some subtle metallic fumes it imbibes in the mine; and according to the different quality there arises a gem of this, or that denomination. Thus, e. g. if the accessionary matter be gold, it becomes a ruby; if copper, an emerald; if lapis lazuli a turquois, &c. lastly, crystal itself in all its purity and perfection, fixed by some acid sulphur, makes the diamond.

The distinguishing mark in precious stones, is the same as in metals, viz. the weight; nor is there any counterfeiting of stones more than metals, but the weight will discover it. All stones, e. g. that are less ponderous than a diamond, &c. are infallibly no diamonds, &c. And, on the contrary, whatever stone has the weight of a diamond, is really a diamond**. Tho' the hardness, consider'd with the weight, makes the proof still more unexceptionable.

Hence,

Dr. Woodward divides precious stones somewhat more precisely, into opaque, semi-opaque and transparent. Again, 1st, the opaque are either of one colour, as the turquois; or of various colours, as lazuli and jasper. 2d, Semi-opaque, either have their colours permanent, as the agat, chalcedony, onyx, sardonix, cornelian, and beryl; or their colours vary, according to the position of the light, as the Oculus cati and opal. 3d, Transparent stones are either with colours; as the topaz and jacinth, yellow, or partaking thereof; granate, ruby and amethyst, red; saphir, water saphire, and aquemarine, blue; and emerald, or crysolite, green, or partaking thereof: or without colours, as the crystal, pseudo-diamond, white saphire, and diamond.

† For the origin and formation of gems, see the note at the conclusion of this chapter.

|| Dr. Stare, seems to stretch this point, and make the specific weight of stones too adequate a standard. He speaks of several bodies, which appear, in all respects, like stones, and are commonly rank'd as such; but which, by the hydrostatical ballance, are found to want of the necessary weight, such, e. g. is chalk, and various other bodies taken for granted to be stones, some of which are nearer earths than stones, and others nothing but earth, sulphur, and metal. Of the former, many fall short of our standard of stone, and others exceed it: whereas, true stones, says he, tho' differing much in hardness, whether pebbles, flints, petrify'd waters, &c. do answer the same standard of specific gravity as a diamond does: which is to that of water as $2\frac{1}{2}$ to 1. Phil. Transact. N° 182.

** The hydrostatical ballance, says Mr. Boyle, is of prime use for discerning genuine

*Imperfection of
the Art of mak-
ing precious
stones.*

Hence, the art of making facitious gems become defective on a double account: for, as we have not the art of fusing crystal, we are forc'd to work on glass, as our basis, which is far short, both in respect of weight and hardness. Were but crystal fusible; as we could tinge or colour it at pleasure, artificial gems might be made nothing inferior to native ones. 'Tis true, we have a method of giving a tincture or dye to crystals, which to the eye shall be equal to that of the richest gems: accordingly, we have seen beautiful green emeralds produced, by fusing copper in a crucible, and retaining the crystals therein, for some time; but the colour, here, is only superficial; it adheres to the stone, but does not penetrate into its substance. Add, that the stone is hereby render'd full of cracks, and flaws; and so, extremely brittle. Consult Mr. Boyle, of gems*.

nuine gems from counterfeits, which too often pass for true, to the great prejudice of physicians and their patients, and the great loss of lapidaries: for, as there are, perhaps, no qualities of bodies more essential than their ponderosity, so there is scarce any, wherein impostors find more difficulty to make a notable alteration, without being discover'd. In several cases, indeed, 'tis not very difficult to alter the specific weight of a particular body; yet it may be impracticable to make any considerable alteration in the quality, unless by such additions and operations as will cause a sensible alteration in some other qualities, and so subject the cheat to a discovery. He proceeds to give instances of discoveries he himself had made by this means. *Med. Hydrostat.*

* Many authors, not only among the ancients, but the moderns, are full of the virtues and medicinal properties of precious stones; but their reputation, in this respect, is now not a little fallen. Yet, as the fragments of such stones are still preserv'd by the physicians, in some of the most celebrated compositions; as there are certain chymical preparations made of 'em; and as several persons of the greatest candour and experience, have related some considerable effects of certain gems, on their own particular observations; and lastly, as it is no ways improbable that some of the softer stones may have considerable operations on the human body: it might be imprudent indiscriminately to exclude 'em from any medicinal virtue at all. When much the greatest part of their traditinary qualities are set aside as fabulous, there will still remain some, on as real,

and well warranted a footing, as many of our other medicines.

'Twas on such considerations, the excellent Mr. Boyle was induc'd to give us that fine piece of the *Origin and Virtues of gems*; the purport whereof is to make appear, "that such stones were originally in a fluid state, or are made up of such substances as were formerly fluid; and that many of their general virtues are probably derived from the mixture of metalline, and other mineral substances usually incorporated with 'em; while the great variety, and the particular efficacy of their virtues arise from some happy current circumstances of that commixture; e. gr. the peculiar nature of the impregnating liquor, the proportion wherein it is mix'd with the petrescent juice, and the like."

To support this hypothesis of the virtues of gems, he shews that several of 'em are not simple concretions of any petrescent liquors, but consist also of other mineral adventitious parts; which he argues from the separableness of such substances in some stones; the specific gravity in others; and the different tinctures to be met with in gems of the same species, as rubies, sapphires, garnets, and even diamonds, of which some are yellow, some of other colours, and some green almost like emeralds. There may therefore be in some gems numberless adventitious corpuscles: but there is great reason to think that some of these corpuscles may be endued with several properties and medicinal virtues: there is a great difference among these impregnating particles, and probably a greater variety than is known by us; and lastly, many gems are

are very richly impregnated with these particles: why, then, may not they exert some power? This is the substance of what is directly alledg'd in behalf of gems.

The stress of what is objected against 'em is, "that the mineral substances they contain, are so closely lock'd up, that they can communicate nothing to the body, and so can have no medicinal operation; being unconquerable by so small a heat as that of the stomach, and other parts of the body".

Which objection might be plausible enough, to prevent one's ascribing any medicinal virtues to 'em *a priori*; but can conclude nothing against what is warranted by so many facts, and observations; especially, when there are several particulars, that obviate this objection. For a vigorous load-stone, tho' frequently harder than many gems, is known to emit copious effluvia; and there are many which have been found to have a manifest and inconvenient operation on the humane body, by being wore in the pocket, or long held in the hand. Mr. Boyle has found many transparent pebbles, which when cut would resemble diamonds, that might be immediately brought to emit copious, and strong-scented streams. And if electrical attractions be owing to the effluvia of bodies excited by rubbing; very slight alterations may suffice to procure expirations from transparent gems, many of which are electrical, and even the hardest of all, viz. diamonds, one of which Mr. Boyle kept by him, which upon a little friction, would attract very vigorously.

To that part of the objection, which pretends gems not to be digestable by the heat of the stomach, it may be replied, that we do not know how far the digestion of things in the stomach is owing to heat. Nor is it prov'd that such materials can have no operation on the body, without being digested, i. e. in passing thro' it, without undergoing any sensible change of bulk, figure, &c. as gems, when swallow'd, are suppos'd to do. For some chemists make a kind of bullets of regulus of antimony,

which they call *pillula perpetua*; because when they have perform'd their operation in the body, and are cast forth with the excrements, they may be applied again and again to the same purpose. Nor do we know what analogy there may be between some juices in the body, and those mineral parts which impregnate gems: for tho' *Oculus mundi* be reckon'd among the rare gems, yet if one of the best sort, be, for a while, kept in common water, it will receive an alteration obvious to the eye. Add, that Mr. Boyle has, without heat, obtained a manifest tincture from several hard bodies, and even from a transparent sort of gems by means of a faint liquor, distilled from a vegetable substance, as harmless, and as plentifully eaten as bread. And whether some juices of the body, assisted by the natural heat thereof, may not serve for menstrua to some gems, we will not say: but even the natural heat of a human stomach, nay, perhaps of the external parts of the body, may be able, tho' not to digest precious stones, yet to fetch out some of their virtues: for 'tis certain, it makes a sensible alteration in the hardest sort of 'em: witness a diamond of Mr. Boyle's, which might have its electric faculty excited without rubbing, only by a languid degree of adventitious heat; and another, which, by means of water made a little more than luke-warm, might be brought to shine in the dark.

Lastly, if it be yet objected, that 'tis not likely gems should part with any effluvia, or portions of themselves, inasmuch as they lose none of their weight: it may be answer'd, that the antimonial glass and cup, imbue wine and other liquors, with a strong emetic quality; without undergoing any sensible diminution of weight. Add, that the common water be not allow'd a menstruum fit to draw any thing from mercury; yet, both Helmont, and others inform us, that a large quantity of it being kept for a day or two upon a small proportion of that drug, will acquire a virtue of killing worms, tho' the mercury retains its former weight.

VULGAR STONES.

Vulgar Stones. * **V**ulgar, or opake stones, are of a more earthy kind; and convertible by fire † into a calx, which, with the addition of a fix'd alkaline salt, becomes glass ‡. Such are pebbles ||, flints, the *Lapis calcarius* or lime stone, &c. See *Antonio Neri, de Re vitraria* **.

* E'er we pass on from *precious* to *vulgar* stones, it may be proper to remind the reader, that there are certain stones, which partake, more or less, of the characters of both; and which some authors refer to the one class, and others to the other: but to us they seem better consider'd, as constituting a class of themselves. Accordingly, in bishop *Wilkins*, they make what he calls the *middle priz'd class*, which includes the alabaster, marble, porphyry, agat, jasper, lazul, crystal, glass, selenites, talc, magnet, cadmia, asbestos, &c.

† For the chemical elements of stones, *M. Homberg* observes, that all we find in 'em is a deal of earth, with a little sulphurous fume. *Mem. de l'Acad. An. 1702.*

‡ See what is hereafter deliver'd of the making of glass, in the notes at the end of the article, *semi-metals*.

|| *Vulgar* stones are divided by bishop *Wilkins* into those of *greater magnitude*, used either about buildings, as the free-stone, ragg-flint, fire-stone, slate, and pebble; or about metals, as the whet-stone, touch-stone, emery, and pumice; and those of *lesser magnitudes*, as sand and gravel.

Origin and formation of stones.

** The origin of stones, is a point of curious and important inquiry, and has accordingly been prosecuted by some of our later naturalists, with peculiar attention. *Boyle, Tournesfort, and Geoffroy*, have distinguish'd themselves in this research.

M. Tournesfort deduces stones, and other of the fossil tribe, *ab ovo*. Nature, according to that author, observes one general law in the production of plants, stones, and metals, which all equally arise from their several seeds, and grow alike. This sentiment indeed is not quite new: *Pliny* assures us, that *Mutianus* and *Theophrastus*, maintain'd that stones produc'd stones; and *Gregory Nazianzen*, in his poem *de virgin.* relates, that there were authors who believ'd that trees made love. *Ἐς καὶ ἀφ' ὧναι γαμος*

καὶ γαμος ἔστω. But *M. Tournesfort* sets the system in a new light, and supports it by arguments they were strangers to: In the walls of the labyrinth of *Crete*, which are of living rock, a great number of names have been cut by persons who have visited the same. Which names, tho' originally dented, or in creux, are now found in Bas-relievo, standing out from the face of the rock by $\frac{1}{2}$ of an inch. Now, this he argues, could no otherwise happen, but by supposing the dents gradually fill'd up with some matter oozing out of the rock, and which even oozed more plentifully than was necessary for filling the cavity. This matter, therefore, must have come from the body of the stone, and have consolidated, or healed up the wound made by the knife or chisel, much as the callus form'd on a fractured bone by the extravasated nutritious juice of the bone, fills up the fracture, and rises beyond the surface of the bone. The like is observ'd in the barks of trees, cut in the same manner; whence the expression of *Virgil, crescent illa crescentis amores*. Lastly, the like callus's or consolidations were shewn by *M. Tournesfort* to the royal academy, in other stones, as an *Ætites*, or eagles stone, and some others fresh dug up. From the whole he concludes, that stones grow in the quarry; that, of consequence they are fed; and that the same juice which feeds 'em, serves to rejoin their parts when broken; and in a word, that they are organiz'd, and draw their nutritious juice from the earth; thro' their surface, which filters it, and serves as a sort of bark. The progress and distribution of such juice thro' all parts of so hard a body, he adds, is difficult to conceive; but not more so than that of the juice of some trees of very hard wood, as that of *Brasil*, call'd iron wood, that of ebony, or even coral, which all allow a plant.

Having found that some stones grow like plants; the analogy led *M. Tournesfort* to imagine they might be propagated alike:

and

and 'tis certain, there are some sorts, whose generation can scarce be accounted for, without supposing them to have arose from a sort of seed, i.e. from a germ, wherein the organical parts of such stones were contain'd in little; as those of the largest plants are in their grains. The cornua ammonis, lapis judaicus, astroites, entrochi, toad-stone, crystals, the several species of pyrites, sea-mushrooms, and infinite others, suppose their particular seeds, as much as common mushrooms, truffles, and divers species of moss do, whose seeds were never yet discovered.

The cornua ammonis, for instance, is constantly in form of a volute, and the lapis judaicus of an olive fluted without side: Now, whence this uniform structure, unless from a seed containing it in embryo? Who moulded it so accurately; and where are the moulds it was fashion'd in? nothing like 'em are ever found, even where the stones are in greatest abundance. Boer, after abundance of enquiries about the regular figure affect'd by crystals, concludes, that it is as natural thereto as that of the leaves and flowers of any plant; and ascribes the whole to an archetonic spirit, and a kind of faculty, which he calls *formatrix*. But, is it not better to suppose they have a kind of eggs; and that the juice they derive from the rock to which they grow, does, as it were, hatch, and extend 'em to their destin'd bulk? To say no more, that immense quantity of round pebbles where-with the *Crau of Arles* is cover'd, for seventy miles round, seems to require the same origin; and accordingly *Fab. de Peireisc*, who held that stones arose from seeds, tho' in a sense different from M. *Tournefort*, look'd on this plain as a convincing proof of his opinion. *Memoir de l'Acad. An. 1702.*

But this Doctrine seems, in good measure obviated by Mr. Boyle; who undertakes to prove that gems, in particular, were originally in a state of fluidity. This he argues from a great number of considerations: as 1^o, The transparency of those stones; which is a quality depending on such an order of the constituent particles, as cannot well arise without supposing 'em originally capable of being mov'd with the smallest impulse, and of giving way to the rays of light. 2^o, The figure, which in many is determinate and geometrical, bearing

a near analogy to the crystals which we see arise from the dissolutions of nitre, alum, vitriol, or the like in water. 3^o, The texture, which nearly resembles that of several conglutinations of bodies formerly fluid. Thus, dissolv'd salts, silver, &c. are found to coagulate into masses, of a thin, flaky contexture; and the like texture, Mr. Boyle has observ'd in divers gems, which even to the naked eye, have appear'd full of parallel commissures, made by the contiguous edges of little thin plates of stone, lying one over another, like the leaves of a book a little open'd. Add, that the microscope discovers a parallel structure, even in the most compact of all, the diamond; whence what they call the grain of those stones, and the difficulty, nay impossibility of cleaving 'em against this grain without breaking. 4^o, The colours of many of 'em appearing to be adventitious, and deriv'd from some tinging mineral, which could not be so well imparted to 'em, unless in a state of fluidity. Accordingly, many gems have been depriv'd of their colour, by continuing long in the fire; and the experienc'd Boer affirms, that this will hold of all gems, except the Bohemian granat. Hence it is that the fire alters the colours of many gems, after the same manner as it does those of divers fossil pigments. Hence, again, it is that tinctures are procurable from certain gems, by proper menstrua, which appear rather to be extracts than proper dissolutions. Add, that some gems, which the lapidaries, without scruple, affirm to be of the class of rubies, sapphires, &c. are either colourless, or have different colours from those which usually belong to 'em. 5^o, From heterogeneous matters being frequently found inclos'd in solid gems; particularly flies, straws, grasshoppers, drops of liquor, &c.

The fluid state of stones, then, seems almost incontestable: and accordingly M. *Tournefort* himself is forc'd to allow of it in some cases. He even makes use of the notion, to account for the formation of divers uniformly figur'd stones, as the species of pectinites, conchites, mytilites, ostracites, nautilites, echinites, &c. The fluid seeds of those stones he supposes to have been receiv'd into the cavities of their corresponding shells, the *pecten*, *concha*, *mytilus*, *ostrea*, *nautilus*, *echinus*, &c. and thus moulded into the figures wherein

in we see 'em. Nor does Mr. Boyle himself consider the liquidity of stones as inconsistent with their arising from a semen. *If there be a seminal and plastic power, says he, in stones, why may not it be harbour'd in liquid principles; when we see that the seed of animals, from which arise hard, solid bones, is at first a fluid.* But this must be a piece of inadvertence in those two excellent authors: A fluid seed seems a contradiction. True, a seed may be contain'd in a fluid vehicle; which we actually suppose is the case in animals: but the proper seed or stamen it self, inevitably must be a solid. This is obvious from the very notion of a seed, which is nothing but a little organiz'd body, wherein all the parts of the future production are contained in small: the production it self is only the seed enlarg'd, so as to shew its several parts to the eye. But fluidity is inconsistent with any such organism: A fluid is a body whose parts are either actually in continual motion, or, at least, are liable to be continually mov'd by the smallest force; And how can the structure and arrangement of parts, which constitute an animal or vegetable, persist in so slippery a thing, where the situation of the parts is continually interchangeable? 'tis no more possible for the seed, *e. gr.* of a tree, to be fluid, and yet remain a seed, than for the tree it self to be fluid, while a tree; so that the seminal origin of stones does not seem tenable.

Monf. Geoffroy, here, furnishes us a happier system, and more consistent with the doctrine laid down by Boerhaave. His principle is, that earth alone, without any other mixture of salts, sulphurs, or the like, is the basis of stones; and the only matter necessary to their formation; *i. e.* the earth may be mix'd with salts and sulphurs, as we actually find it is in many stones, but this is not absolutely required; 'tis only by accident that it does befall; and there are other stones without any at all, as the common stones of quarries, white flints, &c.

Earth, according to this philosopher, consists of two kinds of primitive parts; the one in very thin equable plates; the other in all kinds of irregular figures. When the parts of the first kind meet together in a sufficient quantity; the regularity, and equality of their figures, determines them to range themselves in a regular and

similar manner, and thus to form a homogeneous compound, which, at the same time, must be very hard, on account of the immediate contact of its parts, and transparent, by reason of their regular disposition, which leaves a free passage for the light every way: And this is crystal; which, accordingly, is look'd upon as the most simple, pure, and homogeneous of all precious stones. As to the terrestrial parts of the second kind, 'tis visible they can only form opaque and softer assemblages. Crystals, therefore, being alone form'd of the parts of the first kind; all other stones must arise from a mixture of both. Those of the first unite, and bind together those of the second; which without 'em would be no more than a sand, or dust; and give 'em a hardness and consistence.

To explain this more fully, he observes that water is a proper vehicle for the conveyance of the terrestrial parts of the first kind: this is easily gather'd from divers petrifying waters, which line the pipes they run thro', or other bodies laid in 'em, with a crust of stone. Strictly speaking, the water does not dissolve these earthy parts: it only keeps 'em in fusion, as it does the juices of divers sorts of plants. From this resemblance, he calls these parts the crystalline, or stony juice.

This juice is more heavy, and fix'd than water; and consequently does not evaporate with it; but is left behind; and thus is the formation of crystal, perfectly like that of the crystals of salts. For these crystals only arise with those regular figures they affect, when a water impregnated with salts, is slowly evaporated, in a moist place: the evaporation of the water is necessary, that it may not keep the salts too far asunder; and the slowness of the evaporation, that the salts may have time to take that arrangement which agrees best with their respective figures. The application of this to rock-crystal, is obvious: there needs nothing but to conceive that a water charg'd with a good quantity of crystalline juice had insinuated it self thro' the clefts of some rock, and fallen to the bottom of a grott, where the aqueous part gradually evaporated.

It must be consider'd that this crystalline juice is not equally diffused in all parts of the earth, so that rock-crystal would not arise

arise in all places, even setting aside the necessity of other concurrent circumstances which do not often meet. If the water impregnated with this crystalline juice happen to penetrate a mass of earth; which is the most usual case; it will connect or bind together the parts thereof, by means of this juice; and afterwards, in proportion as the watry part evaporates, the compound will grow harder, and at last become stone. Add, that it will approach nearer to the nature of crystal, *i. e.* will be more hard and transparent, according as the quantity of that juice is greater; and at the same time of a finer grain, according as the molecules of the earth are smaller and more homogeneous. Of this kind are marbles, and alabasters, in some of which one may discern veins or threads, as transparent as if they were wholly crystal. The stones most opposite hereto, and most imperfect, are chalk and boles; which are little else but earth ill bound together with a very small quantity of crystalline juice; which leaves 'em still friable. 'Tis easy to imagine infinite degrees between these.

The particular circumstances which attend the formation of stones, vary the effect of these general principles divers ways. For instance, if a portion of this crystalline juice, diluted in water, chance to be surrounded with earth; and the juice be not in quantity sufficient to petrify the the whole earth as fast as the water evaporates; there will arise a mass, partly crystalline and transparent, and partly opaque, dissimilar and earthy. If the same crystalline juice be in the middle of the mass; only the middle will be transparent, and cover'd over with an opaque crust. Such are agats, &c. On the contrary, if the crystalline juice, be, by any cause whatever, driven from the centre toward the circumference; there will be a pure earth in the middle of a stone, tolerably transparent. Such are divers flints, &c.



R

Fourth

Fourth Class of Fossils.

EARTHS.

Earth,

After stones, the next bodies in point of simplicity, are *earths*; which are distinguishable into two classes or kinds; viz.

1^o, *Sands**, which are properly little crystals, or transparent pebbles, calcinable; and, by the addition of a fixed alkaline salt, fusible, and convertible into glass: and, therefore, in propriety belong to the article of stones †.

Defined,

And, 2^o, *Earth* properly so call'd: which is a fossil body, neither dissoluble by fire, water, nor air; insipid ‖, and untransparent; more fusible than stone; still friable; and containing usually a share of fatness **.

Earths, in this sense, are divided into *simple*, or immutable; and *compound* ††.

Of

* 'Tis the character of sand not to be calcinable by fire, as flint, and other stones are; and yet it agrees with flint, and some metals in this, that it strikes fire from steel. But it must be observed, this only holds of the *proper* or *mountain* sand; for a great part of what commonly passes for sand, is not originally such, but only a dust or powder ground or broke off other stones by their attrition against each other; and denominated sand for no other reason but the smallness, little cohesion, and dryness of the grains. The real sand, Dr. Lister observes, is of a constant figure, and always preserves its original magnitude.

From the great hardness, and, consequently, durableness, and unalterable Quality of this fossil above all others, together with some other considerations; that author concludes it to have antiently been the exterior, and most general cover of the surface of the whole earth. *Philos. Transact.* N^o 164.

† Dr. Lister divides the *English* sands into two classes: the first, *sharp* or *rag-sand*, consisting of small, transparent pebbles, naturally found on the mountains, and not calcinable. These he further divides into *fine*, and *coarse*; and subdivides each, according to the colours, into white, grey, reddish, brown, &c.

The second, *soft* or *smooth*; which he subdivides into that with *flat* particles, broke from lime-stones; that with *filic-like* particles; and that with *gold-like*. *Phil. Trans.* N^o 164.

‖ 'Tis disputed among the peripatetic and chemic philosophers, what species of bodies the calces or ashes of burnt bodies ought to be rank'd in: the first refer them to earth, because of their permanency, and fixedness; but the latter will have them a body *sui generis*, as commonly containing a caustic salt; whereas earth ought to be insipid. *Boyle on the Resurrec.*

See the chapter of *Earth* consider'd as an instrument or element.

** The mixture of sand and clay, Dr. Lister observes, is not unusually call'd *earth*; a term somewhat too vague, and which it would be convenient to limit to that mixture which we ordinarily find upon the surface of the ground; and which, beside the two ingredients above-mention'd, contains a great deal of the parts of purrified plants and animals. *Philos. Trans.* N^o 164.

†† There is, perhaps, no such thing as a strictly simple earth. "It does not appear," says Mr. Boyle, "that nature, any more than art, affords any elementary earth: at least, some which appear of the simplest sorts, are found upon examination."

"nation"

Of the first kind is *chalk* III, which is the simplest, and driest of all *Simple earths*; as having no discernible share of fatness at all. To this kind are reducible *pumice*, *rotten-stone**, &c.

Among the *compound* or fatty earths, are number'd *boles* of divers kinds, *Compound ones*, red, white, and brown; most clays†; *fullers earth*; the divers kinds of medicinal earths, as *Cretica*, *Tockaviensis*, *Hungarica*, *Turrica*, *Silesiaca*, *Suecica*, *Lemnian earth*; *Malta earth*; *Terra sigillata*, soap-earth, &c. To these are likewise refer'd all *argilla* or fatty clays, wrought up, and dried into potters ware.

There are divers other species of compound earths II; *Rivinius* reckons

"nation to have qualities not ascribed to "pure earth." On *Chym. Prin.* See further in the chapters, *Of Operations*; and *Of Earth*, as an instrument.

III The ancients, and many of the moderns, refer *chalk*, which they call *creta*, and *pumice*, *pumex*, to the class of stones; but 'tis with better reason they are accounted *earths*. Dr. *Stare* complains, that our senses frequently impose on our understandings, in representing that as a stone by its external appearance, which has none of the distinguishing characters of stone. He instances in *chalk*, which, brought to the hydrostatical balance, is found to want much of the consistence, and weight which is required to a real stone.

* Several species of clays seem to have a fair title to the rank of simple earths: tho', on a strict examen, they appear very compound. Thus tobacco-pipe-clay, by reason of its fixity, whiteness, and insipidity, Mr. *Boyle* thinks, may, with almost as much probability as any other native earth, be accounted elementary: and yet tobacco-pipes well baked, may sometimes be made to strike fire; and we have several times found, that by briskly rubbing two pieces of a new tobacco-pipe, they would in a minute or two grow warm; and being immediately smelt to, manifestly afford a rank scent, between sulphurous and bituminous; almost like that which proceeds from pebbles and flints rubbed hard against each other: as if tobacco-pipe-clay were not a true earth, but a fine white sand, consisting of grains too small to be distinctly seen. *Boyle Mech. Produ. of Chym. Prin.*

Porcellane, or the matter whereof *China* dishes are made, is a pure sort of clay; and yet a violent fire will sometimes make

it melt; and it will strike fire with steel, almost like a flint; to which it approaches in specific gravity. The like we have observ'd of porcellane very artfully imitated with a sort of *English clay*. *Id. ibid.*

† Dr. *Lister* makes clay a genus of almost as much extent as earth itself. In his scheme of clays, he divides them into two grand classes, *pure*, i. e. such as are soft, like butter to the teeth, and have little or no grittiness; and *mix'd*.

Pure clays he subdivides into *greasy*, which include the medicinal earths, or *terra sigillata*; as fullers earth, yellow, brown, and white; boles; cow-shot-clay; and a dark blue clay: *harsh* and *dusty*, when dry, as *creta*, properly so called, or the milk-white clay of the *Isle of White*; potters clay, yellow, blue, and red: and *stony*, when dry, as the several sorts of stone-clays, and clunch.

Mix'd clays he subdivides into those with round sand or pebble; as the yellow loam of *Shipworth-Moor*; the red sandy clay near *Rippon*, &c. and those with flat or thin sand glittering with mica; as crouch-white clay, grey or blueish tobacco-pipe-clay; and a red clay in the red sand rock at *Rotherham*. *Philos. Transact.* N° 164.

|| *Vannochio*, an eminent *Italian* mineralist, informs us, that a sort of reddish earth oft contains the richest metals. Mr. *Boyle* has found finely figured crystals to grow in a red earth. An experienced writer on the gold and silver mines of *America*, observes, that gold itself is often disguised under the appearance of a reddish earth. And our *English* okers are richer in iron even than some ores of that metal. Add, that the same Mr. *Boyle* had a whitish earth sent him out of the North of *England*, which contain'd a considerable quantity of lead.

above a hundred sorts of *figillata* or seal'd earths; the history whereof has been long expected with some impatience.

Its principles.

These earths are all resolvable into a little sulphur or oil, a little acid, and less fixed salt, and a calx, which is the basis, or properly the earth itself.

Sand.

As to *sand*, its office is to make the fatty earth be fertile, and fit to feed vegetables, &c. For, earth alone, we find, is liable to coalesce, and gather into a hard, coherent mass; as is apparent in clay: and earth, thus imbodyed, and as it were glued together, is no way disposed to nourish vegetables. But if with such earth, sand, *i. e.* hard crystals, which are indissoluble in water, and still retain their figure, be intermixed, they will keep the pores of the earth open, and the earth itself loose and incompact; and by that means give room for the juices to ascend, and for plants to be nourished thereby.

Thus, a vegetable, planted either in sand alone, or in a fat glebe or earth alone, receives no growth or increment at all; but is either starved or suffocated: but mix the two, and the mass becomes fertile. In effect, by means of sand, the earth is render'd in some measure organical; pores, and interstices being hereby maintain'd, something analogous to vessels; by which the juices may be convey'd, prepared, digested, circulated, and at length excern'd, and thrown off into the roots of plants*.

* See the chapters of vegetables.



Fifth Class of Fossils.

SULPHURS.

Sulphur is a fossil body, fusible and inflammable by fire, and not dissolvable Sulphur defined. or miscible in water, nor malleable.

These six properties concurring, form the idea of a sulphur; nor is there any other body in nature wherewith they all quadrate.

It must be owned, however, that spirit of wine, which is a sulphur, is miscible with water; but it is owing to this, that the sulphur in spirit of wine is so changed, and its parts so attenuated, and divided, as to insinuate themselves among the parts of the water, where they would not otherwise be admitted*.

We call it *fossil*, to distinguish it from the sulphur of metals, call'd also the sulphur of the philosophers.

Inflammable by fire, i. e. reducible by fire into flame, and ashes; which are its principles; the flame being a volatile acid spirit; and the ashes, earth, with a little metal therein, resembling iron.

Fusible; in which state the fume it emits, corrodes, and consumes all metals; converting them into vitriols, which are a species of semi-metals. Thus, iron, which abounds in sulphur, being heated, tho' not ignited; the sulphur is found to kindle, and go off in a blueish flame.

Sulphurs are divided into two classes, viz. *solid* and *liquid* or at least *Divided*. *liquifiable* by the gentlest heat.

The solid Sulphurs are,

1°, **C**ommon sulphur; of which there are two kinds; the first, *sulphur Sulphur vivum* *vivum*, which is a native sulphur, found under ground, in solid, grey, or ash-colour'd glebes, like rock-salt; in divers places, but chiefly the island *Sicily*. This, *Helmont* accounts an antidote against the plague.

2°, *Yellow sulphur*, or the vulgar sulphur of the shops, is only the former kind melted down by a violent fire, and run into cylinders †. This,

* In spirit of wine, and other fermented liquors, what we call the sulphur of the concretes, or bodies they are procured from, lose, by fermentation, that property of oil or sulphur which makes them immiscible in water. *Boyle's Sceptical Chymist*.

† By the way, it is to be observed, that the sulphur commonly used among us, is not that from *Sicily* alone, thus melted

down; but there is another species of native or mineral sulphur found, of a hard, earthy consistence, and a shining yellow colour; chiefly around *Volcano's* or burning mountains, particularly mount *Vesuvius*, and *Ætna*; and sometimes also in its own mines, both in *Italy*, *Switzerland*, and the *Spanish America*. 'Tis chiefly of this that the sticks or rolls of sulphur are made.

the

the more fluid it is made, the better it is; and the more cineritious, or dark-colour'd, the worse: if it be blackish, it has a deal of arsenic in it.

Both these kinds of sulphur are exceedingly inflammable; more so than spirit of wine ||: They melt readily by fire, and as readily grow hard again in the cold. They render metals, when mixed therewith, exceedingly brittle; so that 'tis in vain some alchemists have attempted to find the philosopher's stone in common sulphur, which itself destroys the malleability of metals.

Arsenic.

The second is *arsenic*; the most fatal of the whole tribe, as destroying all animals, both man and beast; which the word itself imports; being compounded of *ars*, man, and *veno*, I overcome.

In an ancient manuscript ascribed to the *Sybil*, is a verse which plainly intimates arsenic: *Tetrasyllabus sum: prima pars mei virum, secundam victoriam significat*. Whence some have been induced to seek the philosopher's stone therein.

Orpiment.

Native arsenic is of a yellow or orange-colour; whence it is also denominated *auripigmentum*, or *orpiment* **. Of this are prepared two other kinds of arsenic, *viz.* white and red.

Realgal.

Red arsenic, call'd also *Realgal* ††, is only the native yellow, rubified by fire. And this, sublimed with some other matters, is the *Sandaracha Gracorum*.

The *white* or crystalline, is drawn from the yellow, by sublimation |||.

The smallest quantity of any of these arsenics being mixed with any metal, renders it friable, and absolutely destroys its malleability *. And hence the refiners dread nothing so much as arsenic in their metals; nor could any thing be so advantageous to them, were such a thing to be had, as a *menstruum* that would absorb, or act on arsenic alone: for then their metals would be readily purified, without flying off or evaporating.

|| Sulphur contains some parts which render it more inflammable than either nitre or oil; and yet abounds with acid, and vitriolic particles, which strongly resist the flame in several other bodies: the fire of sulphur, beside its common effect, seen in matches, in another capacity, acts by means of its acidity upon some metals, especially iron; and also on red rose-leaves, which are turn'd white by its fumes. *Boyle Useful. of Exper. Philos.*

†† Tho', some naturalists will have *red arsenic*, and *realgal*, two distinct drugs; taking the latter for a native mineral, and the former for a preparation of native arsenic.

||| 'Tis this species is chiefly in use among us for real arsenic. Some authors give it a different origin; and maintain it a native matter, found in white scaly glebes, in the mines.

* A single grain of arsenic, mix'd with a pound of copper, turns it into a beautiful seeming silver. This hint many persons have endeavour'd to improve on, for the making of silver; but in vain, as it could never be brought to sustain the hammer. Some have been hang'd for coining species of this spurious silver.

Arsenic

Arsenics do not dissolve in water, but hang therein, after the manner of feathers. Fire readily fuses 'em : and they erode, and wonderfully alter all metals†.

3°, *Bitumen*, which is an imperfect, fatty sulphur, consisting of an oil, *Bitumen*, and the vague acid combin'd : for of such principles it may be compounded by art. Thus the acid spirit of sulphur, and oil of vitriol distilled together, yield a sort of *Bitumen*, which liquifies by the fire, &c.

Bitumen is of various colours and consistences ; whence it is distinguished into various kinds* : the most eminent, and that which gives the denomination to the rest is,

Asphaltum, *pisaspphaltum*, *bitumen judaicum*, jewish pitch or *bitumen pro-Asphaltum*. perly thus call'd, which is a fatty glebe, or scum, gathering on the surface of the dead sea.

This species is furthest matured and concocted of the whole bituminous kind, but it consists of the same simple principles as the rest. 'Tis but rarely found in our shops : its name *pisaspphaltum* intimates it to partake both of *pitch* and *bitumen* ; which some say is owing to its being adulterated with pitch : tho' others take its pitchy property to be natural ‖.

As it is liquid in its first state, it will require a place among the liquid sulphurs.

But there is another *asphaltum*, which is a mineral stone, found in the valley of *Sydim*, near the antient *Babylon*, and lately also in the County of *Neuchatel*, the oil whereof makes an excellent cement, incorruptible by many acids, and supposed to be the mortar, so much celebrated among the ancients, wherewith the walls of *Babylon* were laid.

5°, *Amber*, or *succinum*, about which there is some dispute ** whether *Amber*. it be a vegetable or a mineral production : but it has the fairest pretensions to

† Arsenic, whatever some may urge, should never be given inwardly ; as being a most deadly poison, gnawing, and tearing the parts, and occasioning mortal convulsions. Its fume taken into the lungs kills instantly. And the oftner it is sublimed, the ranker it grows. The younger *Helmont* seems to intimate, that arsenic would fix mercury ; but the operation must be extremely dangerous, the least breath of it being fatal.

* Some naturalists, as *Dr. Woodward*, &c. extend *bitumens* into a general class, answering, in great measure, to the class of sulphurs. Accordingly they subdivide 'em into liquid, or *naphtha*, including petrol, and *oleum terræ* ; and solid, under which they range amber, jer, bitumen, asphaltum properly so call'd, and coal.

‖ It is of a shining black colour, and so like *Stockholm* pitch, that were it not for

the rank smell of that pitch, and the superior hardness of the bitumen, there would be no distinguishing 'em.

'Tis usual to sophisticate the asphaltum, by mixing pitch along with it ; the result whereof makes the *pisaspphaltum* ; which the coarseness of the black colour, and the fetid smell easily discover.

** Amber is usually yellow and transparent, sometimes red : its taste is resinous, and its smell like that of oil of turpentine. It is chiefly found in the *Baltick-Sea*, and along the coasts of *Prussia*. Naturalists have been extremely in the dark about its origin and formation, some have maintained it an animal substance, form'd, by concretion, of the tears of birds ; or according to others, of the urine of a beast : others take it for a resinous juice, oozing from poplars, and firs, frequent on those coasts, and discharged into the Sea ; where undergoing

to be a fossil; inasmuch as by distillation it yields an acid spirit, which precipitates into a salt; which is a peculiar circumstance in the distillation of minerals, never found in that of vegetables or animals.

To this species may likewise be referred *jet**, or black amber; and *ambergrease* †, or grey amber.

Liquid Sulphurs.

Asphaltum.

THE first is *asphaltum*, or *pisphaltum*, or *jewish pitch*, a sort of bitumen, or viscid fatty juice, found on the surface of the lake *Asphaltos* or dead sea, in *Judea*; which tho' at first liquid, yet hardens in the air, and is brought to us in a firm consistent mass. So that it is rather to be ranked among the solid than the *liquid sulphurs*.

Naptha.

The second is *naptha*, a ruddy fat, or axungia, exuding out of a rocky, or stony earth; exceedingly inflammable, so as to catch fire even from a candle held at distance; and so combustible as to continue burning under water.

dergoing some alteration, it is thrown ashore, in this form: but the generality of authors contend for its being a bitumen, which trickling into the sea, from some subterraneous sources, and there mixing with the vitriolic salts, which abound in those parts; it becomes congeal'd or fix'd thereby; the result of which congelation is amber. But what a little disturbs this doctrine, is, that good amber is frequently found in digging far from any sea-coast; which confirms it a thorough fossil.

There are several indications, which discover where this amber is to be found: the surface of the earth is there cover'd with a soft scaly stone; and vitriol in particular abounds there. Amber assumes all figures under ground, that of a pear, an almond, a pea, &c. among others, there have been found letters very well form'd, and even *Hebrew* and *Arabic* characters; within some pieces of amber have likewise been found leaves, insects, &c. included: this, with some, passes as a proof that amber was originally in a fluid state; tho' others rather account for it by supposing the amber to have been exposed to the heat of the sun, and by that means softened, so as to become susceptible of the leaves, insects, &c. which opinion is countenanc'd by this, that those heterogeneous matters are never found in the center of the piece, but always near the surface.

* Jet or gagates is a sort of black, mineral stone; which admits a good polish, and has all the properties of yellow amber. There are quarries of jet in divers countries.

† Ambergreese is found on the sea-coasts; particularly those of *Africa*, from the *Cape of Good Hope* to the *Red Sea*, and the adjacent Islands; in some places of the *Mediterranean*, and about the Island of *Bermudas*, in *America*.

There are various opinions as to its origin; some take it for the excrement of a bird, which being dissolved by the sun's heat, and wash'd off the shore by the waves, is swallow'd by whales, who return it in the condition we find it: others imagine it a sort of gum, which distilling from trees, drops into the sea, where it congeals into ambergrease.

Others suppose it a sort of spongy earth, which the working of the Sea washes off the rocks; where, being lighter than water, it floats; others contend, for its being form'd from honey-combs, which fall into the sea from the rocks, where the bees had form'd their nests; which opinion begins to be generally allow'd, several persons having seen pieces, half ambergrease, half honey-comb.

Lastly, others will have it a sort of bituminous juice, which springs out of the bottom of the sea, as *naptha* does out of some springs; and there thickens and hardens.

'Tis

'Tis found in several parts of *Chaldea*, particularly the place where stood the ancient *Babylon*; as also in *France*, and some other Countries of *Europe*. That of *France* is like melted pitch, very black, and of a rank smell.

The third is *petroleum*, or *oleum petrae*, a fatty liquor, trickling out of *Petrol.* rocks; frequently confounded with *naptha*, tho' it be very different therefrom, as being thinner, more penetrating, and less inflammable*.

The fourth is *oleum terræ*, or oil of earth, which is of two kinds; the one call'd *Asiaticum*, as being brought from *Asia*; and the other *Pisellaon*, or *Barbadense*, because brought from *Barbadoes*. *Oleum terræ.*

The first appears to be a sort of liquid bitumen, of a ruddy colour; the second is black: but whether the origin of the two be alike, or not, we will not say. This, however, we are assured of, that a certain celebrated Historian, who says this oil distils out of rocks, is mistaken; that being a circumstance peculiar to *naptha*, and *petroleum*, which are crasser, and more consistent than this oil.

We have made a nice enquiry into this *oleum terræ*; particularly whether so thick an oil could be produced, as is commonly supposed, by the earth; and whether the soil where it was generated, were fertile; and received for answer, from a very intelligent person, governor of the *Dutch East-Indies*, that this oil of earth, is really the oil of coco-nut; only mix'd up with earth, and again expressed out of the same. Such is the natural history of this oil; in which all historians have been overseen; imagining it to distil out of the natural earth.

Sulphurs, of all kinds, being laid on the fire, break into flame; which yields a pernicious smoak; and this, when collected, is always found acid. *Elements of sulphurs.* What remains after the flame or combustion is extinguished, affords an oil, out of which an acid spirit may be drawn; and which at bottom leaves a sort of earthy or metallic matter, which a further fire converts into glass †.

But if either the acid fumes, or the oil, or the spirit of sulphur, be cast on oil of olives, or any other oil, there arises a pitchy matter, which by sublimation affords a bitumen; and the bitumen sublim'd again,

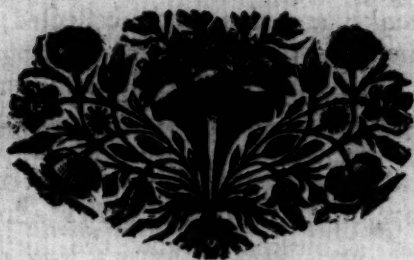
* It is found in several countries, particularly the Dutchy of *Modena* in *Italy*; and is of several colours, red, yellow, green, white, &c. which diversity is supposed to arise from the different situation of the rock, with respect to the sun: thus the white, which is reputed the best, is said to proceed from that side most exposed to the sun's rays; then the red, then yellow, &c.

† The chemists find the analysis of sulphur very difficult: 'tis so volatile, and its parts, withal, hang so together, that it

requires a deal of pains, and address to separate 'em. Sir *Is. Newton*, to account for this, argues that sulphur, like vitriol, is a mixture of volatile and fix'd parts, cohering so strongly by their mutual attraction, as to ascend together in sublimation. He adds, that by dissolving flowers of sulphur in oil of turpentine, and distilling the solution, sulphur is found to be compos'd of an inflammable thick oil, or fat bitumen, an acid salt, a very fix'd earth, and a little metal.

and again, yields sulphur; which being kindled, a spirit of sulphur is rais'd therefrom. It appears, therefore, that all sulphurs are resolvable into oil, acid, and earth*.

* Sulphur thus decomposed may be re-compounded by the reunion of its elements. Thus M. *Homborg*, having with great care and accuracy resolved the body of common sulphur into an acid salt, a bituminous substance, and an earth mix'd with a small quantity of metal; M. *Geoffroy* recomposed those principles into true inflammable sulphur; only, for the last ingredient, substituting oil of tartar. *Mem. de l'Acad. An. 1703.* See further in the article of the operations.



Sixth Class of Fossils.

SEMI-METALS.

A Semi-metal is a fossil body not malleable, yet fix'd in some measure in the Semi-metal fire; consisting of a metallic part, and some other matter of another kind, connected therewith: or a Semi-metal is a compound fossil body, wherein, by art, we discover something in all respects like metal, except that it is not malleable; joined with some other of the fossils above related, as salt, sulphur, stone, or earth.

Such is the genuine notion of a semi-metal; about which, the naturalists have always talk'd so obscurely. Indeed, 'tis impossible to give a precise definition; by reason the part that is not metal, may be diverse; but we may be assured it is some one of the five other classes of fossils already described.

We don't know of any way of converting *semi-metals* into *metals*, i. e. of *Not convertible into metal.* rendering the part which seems metallic, malleable: experiments we have made a great number, after *Helmont's* manner, to reduce the metallic part of that celebrated semi-metal antimony, into a real metal; but still without success; having never been able to purge it so thoroughly of sulphur, as to render it ductile under the hammer. That there was still sulphur remaining, appeared hence, that being laid under copper, it would still whiten, or silver it. This, however, we constantly observ'd, thro' the course of the operation, which lasted almost a year, that the more of the sulphur was got out, the brighter, finer, and harder did the matter still become. And we are of opinion, that if any menstruum could be discovered, powerful enough to free it of all its sulphur, we should have a new metal; antimony appearing to be of an intermediate nature, between gold and silver.

In effect, a menstruum, or magnet, that would absorb the sulphur, i. e. *Desideratum.* by its magnetic force would draw the sulphur to itself; would be no inconsiderable secret. I tried salt of tartar, which is allowed to attract iron; but this would not do: iron is a yet stronger magnet, but this is ineffectual to gold and silver. I made a trial with mercury, but could not effect the thing in a whole year's time; tho' in that time I procured a matter nearly of the colour and weight of silver: but still it was friable.

Semi-metals are divided, with respect to the matter adhering to the metal, into four classes.

The first are those, consisting of a metal joined with a fossil sulphur, either common or arsenical; according to which the semi-metal becomes either poisonous or otherwise. 'Tis notorious, that fossil, or combustible sulphur, adhering to any metal, renders it soft, and prevents its malleability; *Kinds of semi-metals.*

lity; and when that is separated therefrom, the pure sulphur of the metal, say the chemists, gives it a property, which the fossil one took away. The sulphur, which prevents malleability, is usually called external; and held to be of a quite different kind from the metallic or internal sulphur. To the class of sulphurous semi-metals belong,

SEMI-METALS of a Metal and Sulphur.

Antimony.

1°, *IS Antimony*, which consists of three different parts, viz. 1°, common sulphur: 2°, sulphur, which, in the fire, yields a poisonous smok, and renders metals friable: 3°, metal; tho' of what kind, we don't certainly know. Its character, & we have already observ'd denotes gold at bottom, and a corrosive acid at top. If there be any metallic body, that can resolve gold into its first principles, it should seem to be regulus of antimony*.

Cinnabar.

2°, *Cinnabar*, which consists of common sulphur, and quicksilver united into a mass. It is sometimes found in large glebes†; and is sometimes factitious‡.

Marcasite.

3°, *Marcasites***, which are a sort of stones or mineral clods, either of a gold or a silver colour. All that is wanting to render these perfect metals, is malleability: in other respects they are more beautiful than most metals*†. They consist of an arsenical sulphur, intimately mix'd with a metal:

* Antimony has its own mines, particularly in *Hungary, Transylvania, Germany*, and several provinces of *France*. 'Tis found in glebes or clods of different sizes, bearing a resemblance in figure to black lead; only that it is lighter and harder; whence it is call'd *marcasite of lead*. It dissolves with difficulty by fire; much easier in water. *Basil Valentine* observes, that there are various kinds; two especially; the one more mercurial, and of a golden property, manifest by the shining streaks it abounds with; the other more full of sulphur. That sold by the druggists for crude antimony, is not really such as it comes out of the mine, but melted down and purified.

† Cinnabar is found in all the quicksilver mines; tho' it has likewise its own mines: whereof those in *Spain* are famous. It may be esteem'd as the *marcasite* of quicksilver, or rather as quicksilver itself, fixed and petrified by means of sulphur, and some subterraneous fire. Accordingly it is easily reduced, without much diminution, into real fluid mercury. See the Article *Mercury*.

‡ The factitious cinnabar, is an imitation of the native; made by a mixture of mercury, and sulphur sublimed, and reduced into masses or lumps.

** Note, the word *marcasite* is sometimes used in a more extensive sense, for what we otherwise call *pyrites*; of which by and by.

*† The resemblance *marcasites* bear to metals, or metalline ores, makes 'em frequently be mistaken for such; in effect, many of 'em have two qualities, which render 'em extremely apt to impose on the unwary, viz. shining streaks like gold or silver; and a weight equal, nay and sometimes superior to that of true metalline ores. The grand criterion of metals, therefore, viz. *specific gravity*, here fails us; in lieu of which, to prevent being deceived by any such specious substance, we are to have recourse to the fire: for placing the *marcasite* in a strong fire, and blowing now and then with a pair of bellows; the sulphur wherewith it abounds, will take fire, and burn with a flame for the most part blue, like that of common sulphur: Inso-

much

metal: when thrown on the coals, they yield a white smoak; which renders metals friable.

The chemists find a real combustible matter in tin; which when separated from the metal, leaves it in all respects like silver: and marcasites contain a like sulphur; for we find in them a combustible matter, which yields a suffocating sulphur; and the glebe becomes so much the more beautiful, as more of the flame is exhausted. If therefore a body could be found that would consume sulphur, the metal would be left alone ||.

4°, *Bismuth**, which is a species, of that sort of marcasite, which approaches nearest to the nature and colour of silver. *Bismuth.*

5°, *Lapis calaminaris*** , which if melted with copper, adds a real metallic substance and weight thereto; but diminishes its malleability: the mass resulting from the two, is brass. It is a very great absorber of acids; and as such is of notable use in chirurgery. *Calamine.*

6°, *Cobalt*, which is, as it were, the mother of arsenic: it consists of silver, and arsenic. The arsenical part being exhaled, leaves behind it a metalline calx ||*. Its fumes are violently poisonous, infect the lungs, and give

much, that Mr. Boyle assures, he procured by distillation, four ounces of good brimstone from three pounds of these stones. And if when this fossil ceases to flame and smoak, it be taken out of the fire, and suffer'd to cool, it will be depriv'd of all its gaudy appearance, and turn'd to a blackish brittle substance, nothing like to a metalline ore. *Boyle Med. Hydrost.*

Marcasites, however, the same author observes, may be look'd on as a kind of metalline bodies; he having found several of them to contain particles of copper, and iron; as *Kentmannus* mentions others that contain silver, others gold, and others both. Mr. Boyle gives another instance of running mercury contained in, and procured from a marcasite: he adds, that it may be possible for a skilful person to make a profitable use of marcasites, either by fixing the volatile gold, or silver contain'd therein; or by graduating silver by their means. *Ibid.*

|| *Sit penes authorem fides.*

* Some naturalists will have bismuth to be of two kinds; the one *native*, or *fossil*, found in tin-mines, and sometimes also, if we may credit *Alonzo Barba*, in mines of its own. It is a hard, heavy, brittle matter, of a coarse grain, white, and glittering: Authors commonly look on it as the marcasite or mother of tin; tho' some go further, and maintain it to be tin it self,

only not arrived at maturity, for want of sufficient coction. The *artificial* is prepared from tin, by cementing thin plates thereof with a mixture of white tartar, salt-peter and arsenic.

** *Cadmia*, *calamine*, or *lapis calaminaris* is of divers colours, some white, some reddish, some greyish, and some blackish, which is reckoned the best; and this again, when broken, is variously colour'd. 'Tis found in veins, or seams, running between rocks; and is dug like lead ore: they always find eyes of lead in the calamine.

In the works near *Wrington* in *Somersetshire*, when they have landed a good quantity of the mineral, they wash, and clean, or *buddle* it, by working and turning it in a running water, which carries off the impure earthy parts, leaving the lead and calamine, with the other heavier, stony, and sparry parts behind. Putting this into sieves, which they dip and shake in a tub of water; the lead gets to the bottom, and the sparry parts to the top; leaving the calamine in the middle, which they proceed to bake in an oven much like that of a bake-house. In 4. or 5 hours, they take it out and beat it to powder with large hammers. *Philos. Transact.* N°. 198.

||* *Cobalt* is a grey shining stone, found in abundance in the mines in *Hermunduria*. 'Tis often mix'd with marcasite, sometimes with

give phthistics; and it is so sharp, that it corrodes and ulcerates the hands and feet of the workmen employ'd in digging it, &c. Divers deadly poisons are prepared from it.

7°, *Pyrites*, which is a sulphurous stone, found in most mines. It is the most fertile and pregnant of all minerals; most metals, salts, and sulphurs being supposed to be derived out of the same; especially vitriol, and copper*.

8°, *Zink* †, which resembles bismuth in most things; only that it is less friable; and even yields a little under the hammer. Mixt along with turmeric, in melted copper, it gives the metal a gold colour. It also serves to purify, and whiten tin; as lead does for gold, and silver. Some call it female antimony.

9°, *Rock-salt*, which usually contains some metallic part, along with a sulphur.

All these bodies contain a sulphur, which renders 'em soft, and their glebes less fix'd; and were it possible, as already observ'd of antimony, to make a separation of the sulphur, from the glebe; we should have perfect metals from each of 'em.

SEMI-METALS, of a Metal and Salt.

Vitriol.

THE second class of semi-metals comprehends *vitriols*, properly so call'd.

Vitriol is described to be a salino-metallic, transparent glebe, dissolvable in water, and fusible, and calcinable by fire. It seems to derive its name à *vitri oleo*, from oil of glass; inasmuch, as when solid, it appears trans-

with silver and copper ore. When they have pick'd out the cobalt, and separated it from the common stone, they beat it to powder by a proper engine; carrying off all the lighter stuff with a stream of water. This powder, to separate the arsenic from it, they spread on a furnace; so that the fire, which is beneath, and behind it, is forced to pass its flame along over the powder, and thus takes with it the arsenic in form of a smoak; which passing out, at a low chimney, is received into a close brick channel, where the arsenic sticks, in form of a white or yellowish powder, whence it is taken once in six months, and melted into a mass.

The cobalt thus roasted, and ceasing to smoak, they take it out, and proceed to melt it, to make *smalt*: in order to which, it is mix'd with pot-ashes, and powder of flint-stones. After it has been five or six times in the melting-pot, it is found turn'd into a blue glass, which being pulveriz'd, is the *smalt*. *Philos. Transact.* N° 238.

* By pyrites is understood the mother, or marcasite of a metal: i. e. the matrix wherein it is form'd, and out of which, when arrived at maturity, the metal is procured: so that pyrites is only a cruder ore. It is differently denominated, according to the seed or stamen of metal it contains: *crystites*, if gold; *argyrites*, if silver; *chalcites*, if copper; *molybdites*, if lead; *siderites*, if iron. Bismuth, we have already observed, passes for the pyrites of tin.

† M. *Hornberg*, maintains, with a good deal of probability, that zink is no other than a natural mixture, of two metals, viz. tin and iron. What gave him the first hint, was, that zink, by the burning-glass, yielded the same fumes as such a mixture. Hence he was led to substitute zink, in his operations, for the same; and he assures us, he always found the very same effects from one as t'other. *Mem. de l'Acad. An.* 1710.

parent

sparent like glass; tho' when fused, it loses that transparency, and changes into an opaque, oily substance. Some call it a *metallic-salt*, as having the common properties of a salt, *viz.* to dissolve in water, and fuse by fire.

After the same manner, may all metals be converted, by acid spirits, into vitriol †: tho' 'tis very difficult to obtain vitriol of gold, or silver, by reason those metals are not easily dissolved by the spirit: But vitriols of iron and copper are easily had.

Native or fossil vitriol †† is of two kinds, *viz.* vitriol of iron, or Mars, and *its kinds.* vitriol of copper, or Venus.

The native vitriols are further reducible, with respect to their colour *, into four kinds, *viz.* green and white, whose metallic part, join'd with the salt, is iron: roman ‖, which is blue; and cyprian, sky-colour'd; the metallick part of each of which is copper **.

† By crystallizing a solution of copper, in *Aqua fortis*, or spirit of nitre, you may obtain a good vitriol; which tho', by virtue of the composition, it has manifestly several qualities, not to be found in either of the ingredients alone; yet Mr. Boyle observes, there are strong indications, that each ingredient retains its former nature, in the compound. *Scept. Chym.*

†† What we call native vitriol, is not strictly so; at least not in the same sense with that of the antients. They had a vitriol call'd *chalcitis*, which came to perfection in the earth it self: this they call'd by three different names, in its three several stages; *misti* in the first; then *melanteria*; and lastly *fovi*.

Our vitriol is none of it found in substance. 'Tis only a crystallization procur'd by art, from a sort of sulphurous marcasite ordinarily found in copper mines, call'd also *pyrites* and *quis*.

Indeed Mr. Boyle assures us, he has sometimes taken vitriol out of the mineral earth, where nature had, without any assistance of art, perfectly prepared it. *Scept. Chym.*

* This diversity of colour arises from the difference wherein the salt, or acid, is receiv'd: in blue, the salt is join'd with copper; in green, with iron; in white, with calamine, or some ferruginous earth, mix'd with lead or tin. As to red vitriol, call'd *colcothar*, its colour is adventitious; and arises from a calcination the vitriol undergoes, either by art or some subterraneous fire.

‖ Roman vitriol is made by exposing the pyrites so long to the external air, that they calcine, and moulder into a greenish dust

or calx. This, they cast into water, where being well diluted, and saturated, they proceed to evaporation by fire; which done, the vitriolic part shoots into crystals.

Green vitriol, call'd also *copperas*, is made, with us, in the copperas works at Deptford, in a somewhat different manner. The pyrites, or stones, call'd also gold stones, are found along the shores of *Essex*, *Hampshire*, &c. The best are of a bright, shining, yellow colour. A heap of these stones, two foot thick, they lay on a bed, or bason well ramm'd; where, in 5 or 6 years, by the action of the air and rain, they begin to dissolve, and yield a liquor, which is receiv'd in the pits, and thence conveyed into a cistern under a boiling-house. In time, the stones turn into a sort of vitriolic earth, which swells and ferments like leaven'd dough. The liquor, at length, being pump'd out of the cistern into a boiler, and a quantity of iron added thereto, in two or three days the boiling is compleated; care having been taken all along, to supply it with fresh quantities of iron, to restore the boiling, whenever it seem'd to abate: when boil'd, 'tis drawn off into a Cooler, where it is left 14 or 15 days to shoot.

** A drop or two of *Aqua fortis*, resting a while on copper, the corpuscles of the menstruum join with those of the metal; and this first produces an asperity, and at length coagulates into minute grains, of a pale blue vitriol: and if on another part of the same surface, you apply a little strong spirit of urine, a vitriol will arise, of a deeper and richer blue. *Boyle Mech. Prod. of Colours.*

We

We have seen a white vitriol from the Island of *Sumatra*, out of which the Inhabitants are said, by boiling, to get pure gold: but the experiment is not easily tried; by reason the vitriol is so very scarce. When dissolved in water, it affords a sort of *Aurum potable*.

Its component parts.

Vitriol consists of three several parts, viz. 1^o, A metallic part, to which there is a sulphur always adhering; 2^o, A menstruous acid; and 3^o, Water or phlegm.

The metal is either iron or copper: The water gives the transparency; for as soon as that is evaporated, the vitriol becomes opake. While the water remains, the vitriol is fusible; but that gone, its fluidity ceases, and it becomes a calx, which emits a fume, that corrodes all metals, and which, being collected, is call'd *spirit* or *oil of vitriol*.

This spirit, is scarce distinguishable from spirit of sulphur *per campanam* *; and by pouring oil on the spirit, it becomes a real sulphur; which, by corroding and dissolving iron, or copper, becomes real vitriol again.

Now such vitriols being only metals dissolved and crystalliz'd in saline menstruums, are frequently call'd by way of distinction, *metallic vitriols*, and *metallic salts*; of which there are as many kinds, as there are different metals, and menstruums used.

SEMI-METALS of Metal and Earth.

Armenian Stone.

THE third class of semi-metals, are those consisting of a stony earth, or glebe, and a metal. Such are, 1^o, The *lapis armenus*, or *armenian stone*; a mineral stone, or earth, wherein are discerned shining points or spangles, of a yellow colour; for which reason, it is also called *lapis stellatus*.

'Tis much the same as *lapis lazuli*; all the difference between 'em, if there be any, being only in the degree of maturity ||: they are both noxious to the body; and both appear to contain arsenic. Of *lapis lazuli* is made

* The principal ingredient in vitriol, is the acid salt, which is the same as in sulphur, and alum: in sulphur, this acid is united with a bituminous matter: in alum, with an absorbent earth; and in vitriol, with a metalline part. *Novo, Cour. de Chym.*

The metallic part is best separated from the acid or saline part, by the affusion of certain alkaline salts, in a liquid form, upon the solution of vitriol made in common water. *Boyle Scept. Chym.*

M. Geoffroy shews, that the mixture of any vitriolic salts, with an inflammable substance, will yield common brimstone: and by the different compositions he has made of sulphur, and particularly from oil of vitriol, and oil of turpentine; and

by the analysis of it, when thus prepared; he discover'd it to be nothing but the vitriolic salt, united with the combustible substance. *Mem. de l'Acad. An. 1704.*

|| The sensible characters that best distinguish 'em, are, that the *lapis lazuli* is harder, and vein'd with gold, which the *armenus* is not: add, that the blue of the latter partakes of a greenness, whereas that of the former is pure. They are both found in *Tyrol*, *Hungary*, &c. but the finest come from *Persia* and the *East Indies*.

Some w^l have 'em the *marcasite* of gold; as being often found in the mines of that metal: but it may be answer'd, that they are as frequently found in silver and copper mines.

that

that noble blue colour of the painters, call'd *ultra-marine* †; and of the lapis armenus, is made that other call'd *azure* ||.

2°, *Lapis hematites*, which is a ruddy mineral of a mean consistence between stone and earth. It contains a noble metallic sulphur, an earth, and an embryo or seed of iron. It is frequently found in iron mines; and is reputed in some measure the matrix thereof. *Schroder, Boyle, &c.* speak of it as an earth out of which iron it self is drawn by fire; and accordingly the antients call it *corpus martis*: But we can assure the contrary, and that the calx it resolves into has no iron at all. However, it is of great use in medicine; and the preparations thereof are even preferr'd by *Sydenham* to those from iron it self. It is also used in polishing of metals **. *Lapis hematites.*

3°, The magnet or load-stone, found about iron mines, and approaching very nearly to the nature of iron self: tho' it is not altogether iron, as some have imagin'd. However, when dissolved in *Aqua fortis*, it yields a little of that metal †.

4°, *Lapis atites*, or *Eagle stone*, which is pregnant, as it were, with another stone, heard to rattle in the middle of it. This too is of a ferruginous nature; and wonderfully commended by the antients for facilitating delivery ††. *Eagle-stone.*

† *Ultra-marine* is prepared by first calcining the lapis in an iron mortar, and then grinding it to an insensible powder on the stone. This done, they mix it up with a paste, made of wax, pitch and oil; and wash the paste well in fair water to separate the colouring part therefrom, which by this means precipitates to the bottom, in form of a fine powder. Lastly, the water is poured off, and the powder, that remains, being dried, is the true *ultra-marine*.

|| The method of preparing it, is much the same as that of *ultra-marine*.

** *Pliny* recounts five species of this stone, viz. the *Ethiopic*, the *Andromedas* or black, the *Arabic*, the *Elalites* or *Militites*, and the *Chistos*; besides that call'd the *magnes hematites*, from its faculty of attracting iron. At present we know of nothing of this kind beside the *blood-stone*, and *ruddle*.

*† The magnet is indued with very wonderful properties, and among the rest, those of attracting iron, and turning its poles toward those of the world; and communicating the same properties to iron.

The antients distinguish'd five kinds, differing from each other both in colour and virtue, viz. the *Ethiopic*, *Magnesian*, *Bætic*, *Alexandrian*, and *Natolian*. They

had also a notion of a male and female magnet: but all the virtue they were apprized of in it, was the drawing of iron, and some small medicinal power. What further discoveries the moderns have made herein, how happily they have applied it to facilitate the great business of navigation, and what fine phenomena it has afforded to the men of speculation, is somewhat foreign to our present purpose. We shall only observe, that the fire, rust, moisture, and long disuse, tend to weaken and deprive it of its force: Tho' Mr. *Boyle* gives us instances of some *English* load-stones, which retain'd their virtue after ignition. See further in the Notes, p. 93.

†† *Laur. Bauschius* has an express treatise on the *eagle-stone*; wherein he maintains, that it is not found in the nests of eagles, as the antients imagin'd, but on the sea-coasts, in fields, and on mountains. Near *Treves*, we are assured, that a man cannot dig a few feet under ground, without meeting with considerable beds or strata of these stones, some of which have only one core or nucleus, others two, and others three. Most of them seem to consist of two or three layers of a stony earth not unlike potters ware, especially the last, which is the innermost. *Dict. de Trev. Verb. Atites.*

T

5°, Oker,

Theory of CHEMISTRY.

5^o, Oker, or ocker, or ockra, a matter form'd of earth, and metal, subsided, or settled from spaw waters, and acidulæ: accordingly, 'tis observed, that spaw waters, dried up by the fire or air, always leave oker at bottom. Oker is also said to be found in iron mines, and places where iron is yet crude, and immature †. 'Tis added, that if you dissolve iron in oil of vitriol, oker, or a matter much like it, will be found at bottom.

GLASS makes the *fourth class of semi-metals*; and is defined a transparent body, fusible by fire, not dissolvable by water, nor malleable, and which hardens by cold*.

We have now gone thro' the natural history of fossils; and such as are disposed to furnish out their museums with collections of this kind, have here the several classes laid down, wherein every thing, according to its order, kind, &c. is to be disposed.

Princi-

† Oker is a metallic earth, found of various colours, red, yellow, &c. The best *Swedish* iron, we are told, is found in form of a mud or oker, at the bottom of lakes, and other stagnant waters. Mr. Boyle adds, that he has observed our *English* okers to be richer in iron than some ores of that metal: See the article *earths*. What further discovers this mixture of iron in oker, is, that by proper application, a piece of oker may be rendered magnetical like iron it self. See the Notes, p. 93.

* 'Tis controverted among naturalists to what class of bodies glass ought to be referred: *Agricola*, Lib. XII. *de re metall.* makes it a concrete juice: *Vin. Belluacensis*, Lib. XI. calls it a stone; and *Fallopins* reckons it among the *media mineralia* or semi-metals: but Dr. *Merret* observes, that the forementioned are all natural productions; whereas glass is factitious, a compound made by art, a production of the fire, and never found in the earth. To obviate this, *Fallopins* distinguishes between glass contain'd in its own mine, or its own stone; and true glass that is extracted from the same. Now, the latter, says he, is no more artificial, than a metal is, extracted from its mineral: and as to the former, he urges, that as metal, by having its existence in the ore, so glass by having it in the stone out of which it is educed, is natural. But this argumentation Dr. *Merret* overturns, by shewing that glass is never found in that form in any mine, but only the sand and stone whereof it is form'd: whereas metals are perfectly form'd by na-

ture into certain species, in proper veins, tho' frequently in such small parcels, that they lie hid, till the fire has collected 'em together, by separating from 'em the other matters wherewith they were mix'd. Accordingly, fire only produces metals by its faculty of separating heterogeneous, and congregating homogeneous bodies; whereas it produces glass by uniting, and mixing heterogeneous matters, viz. salt and sand, into one. *Fallopins*, indeed, denies this, and pleads, that 'tis false to say that glass is at all made of ashes: the ashes are only added instead of the nitre, used among the ancients, the better to extract the glass out of the substance of the stone: But this is easily refuted: for if the glass were procured from the stone alone, the weight of the metal must be less than that of the stones; whereas in reality it far surpasses; 100 weight of sand yielding above 150 *lib.* of glass. Add, that the salts made use of, are of the most fixed kind; which therefore, we cannot suppose to be carried off by the fire: and that in the coarser glasses, which corrode by the air, one may discern, nay pick out pieces of salt, discovering themselves to be such by their taste.

Dr. *Merret* gives us a precise and accurate enumeration of the several characters, or properties of glass; the principal whereof are, that it fuses in a vehement fire; when fused, is tenacious, and cleaves to iron; does not consume or waste in the fire, and is the last effect thereof; is ductile and fashionable into any form, while red hot; but not malleable; friable when cold; diapha-

Principles of FOSSILS.

FROM what has been hitherto delivered, we deduce it, as a corollary, that all fossils consist, 1^o, Of *mercury*, as the base of many of 'em. 2^o, Of a subtile *sulphur*, the coagulator or fixer of the mercury : for even the ancients always distinguish'd two kinds of sulphur, the one volatile, and combustible ; and the other, which alone we have here regard to, perfectly fix'd ; as being in effect a sort of concentrated fire it self ; 3^o, Of *salt* ; and 4^o, Of *earth*.

All

diaphanous either hot or cold ; flexible and elastic ; disunited, and broke by cold and moisture, and especially by saline liquors ; is only cut by a diamond or emery ; does not let acid juices, or any other thing extract either colour, taste, or any other quality from it ; does not wear, by the longest use, nor will any liquor make it musty, change its colour, or rust ; it softens metals, and renders 'em fusible ; receives all metallic colours, both externally and internally ; will not calcine ; may be cemented, like stones and metals.

Making of Glass.

The materials whereof glass is made, we have already hinted to be *salt* and *sand*, or stones. The *salt* here used, is procured from a sort of ashes brought from the *Levant* call'd *polverine* or *rochetta* ; which ashes are those of a sort of water-plant, call'd *kali*, of the species of that found in some parts of *England*, call'd *frog-grass*, or *crab-grass* ; cut down in summer, dried in the sun and burnt in heaps, either on the ground, or on iron grates ; the ashes falling into a pit, grow into a hard mass or stone, fit for use.

To extract the *salt*, these ashes, or *polverine*, are powder'd, and sifted ; then put into boiling water, and there kept till $\frac{2}{3}$ of the water, be consumed ; the whole being stirr'd up from time to time, that the ashes may incorporate with the fluid, and all its salts be extracted : then the vessel is fill'd up with new water, and boil'd over again, till $\frac{2}{3}$ be consumed ; what remains is a sort of lee, strongly impregnated with salt. This lee, boil'd over again in fresh coppers, thickens, and in about 24 hours shoots its salt ; which is to be ladled out, as it shoots, into earthen pans,

and thence into wooden vats to drain and dry. This done it is grossly pounded, and thus put in a sort of oven, call'd *calcar*, to dry. It may be added, that there are other plants beside *kali* which yield a salt fit for glass, *e. gr.* *alga*, or sea-wrack, the common way-thistle, bramble, hops, worm-wood, woad, tobacco, fern, and the whole leguminous tribe, as pease, beans, &c.

The *sand*, or stones call'd by the artists *Tarso*, is the second ingredient in glass ; and that which gives it the body and firmness. These stones, *Agricola* observes, must be such as will fuse ; and of these, such as are white and transparent, are the best : so that crystals challenge the precedence of all others. At *Venice* they chiefly use a sort of pebble, found in the river *Tesino*, resembling white marble, and called *Cuogolo* : indeed *Anto. Neri* assures us, that all stones which will strike fire with a steel, are fit to vitrify : but *Dr. Merret* shews, that there are some exceptions from this rule. Flints are admirable, and when calcined, powdered, and searced, make a pure white crystalline metal ; But the expence of preparing 'em, makes the masters of our glass-houses sparing of their use. Where proper stones cannot be so conveniently had, *sand* is used ; which is to be white, and small, and well wash'd e'er it be applied : such is usually found in the mouths and sides of rivers. Our glass-houses are furnished with a fine sand, for crystal, from *Maidstone*, the same with that used for sand-boxes, and in scouring ; and with a coarser, for green-glass, from *Woolwich*.

For crystal glass, 10 200 lib. of *tarso*, pounded fine, they put 130 of salt of *polverine*, mix 'em together, and put 'em into the *calcar*, a sort of oven or reverbera-

All which are not found in all fossils; metals, *e. gr.* we have already shewn to consist of only the two first principles: and several others, only of the three last.

Whether *water*, the universal wine of the antients, which all bodies drink, and whereby alone they are supposed to grow and increase, be to be deem'd a principle; will admit of some doubt: Sir *Is. Newton* defines it

tory furnace, which is first well heated. Here they remain, baking, frying, and calcining for 5 hours; during which the workman keeps mixing 'em with a rake, to make 'em incorporate: when taken out, the mixture is call'd *frit* or *bollito*.

Note, there are three kinds of *frit*: that here described is crystal *frit*: the second, or ordinary *frit*, for the common white, or crystalline metal, is made of the bare ashes of pulverine, without extracting the salt from 'em. The third, for green glass, is made of common ashes, without any preparation, and a hard sand above-mention'd.

It may be further observ'd, that glass might be made by immediately melting the materials, without thus calcining, and making 'em into *frit*; but the operation would be much longer, and more tedious.

Now, to proceed to the operation of making the glass it self; they take of this *frit*, and set it in melting-pots in the working furnace; adding, in each pot, a proper quantity of a blackish stone, not unlike a load-stone, and call'd *manganese*, which serves to purge off that greenish cast natural to all glass, and to make it clearer, and more azure. While the whole is in fusion, the workman, here call'd the *conciator*, in the green-glass-house the *fouander*, mixes the metal well together, with his *square*; and with a ladle skims off the sand, over which is a whitish salt continually cast up from the metal, and swimming on its surface; which is always in the greater quantity, as the pulverine was weaker; and which, unless well purg'd off, would make the glass brittle, and unfit for working.

When the vitrefaction is compleated, and the metal found sufficiently clear, and fine; they proceed to form it into the works required: in order to this, the operator dips a hollow iron into the melting pot, turns it about, and takes out e-

nough for the vessel or work it is intended for; the metal sticking to the iron, like some glutinous or viscid juice. While 'tis yet red hot, he rolls it to and fro, on a marble, to unite its parts more firmly: then gently blowing into the iron, he raises or swells the metal, just as in blowing into a bladder. This blowing he repeats again and again, till he has attained the destin'd bulk; then whirling it about his head, he lengthens, and cools the glass; and, if the design require it, moulds it in the stamp-irons, and flats the bottom, by pressing it on the marble: and thus delivers it to the master workman, who breaking off the collet, by which it adhered to the blowing-iron, proceeds, as occasion requires, to fashion it further; *e. gr.* if it be for a drinking glass, with his *ponteglo* he sticks the glass, and scalds it; with his *passago* makes the bowl; with his *procello* widens and makes it hollower; then with his sheers cuts off what is superfluous. Thus with blowing, pressing, scalding, (which are to be repeated as oft as the glass cools,) amplifying, cutting, &c. the work is brought to the form intended; and, if need be, feet and handles are fastened on; and *rigarines* and *marblings* wrought.

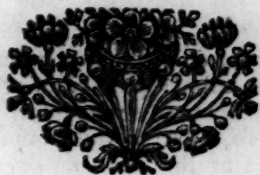
As fast as the master finishes them, another takes 'em up with an iron fork, and places 'em in a tower, over the melting furnace, to *anneal*: into this tower, there is a hole, by which the heat and flame are received from the furnace; and after the glasses have stood here some time, they are put into iron pans call'd *fraches*, which by degrees are drawn, by the *savole-man*, further off, along an appendage of the tower called the *leer*, 5 or 6 yards along, that they may cool by degrees: when they are arrived at the end of the *leer*, they are quite cold, and thus taken out, fit for use. *Antonio Neri de Arte Vitraria*, and Dr. *Merret's Notes on the same*.

an insipid salt ; but with that great author's leave, water's being a dissolvent of salt seems to disqualify it for being a salt it self : we know of no salt in nature that dissolves any other salt.

Others call it the *chaos* of all things, and 'tis certainly the remote matter of all fossils ; and may therefore be consider'd as constituting a peculiar class of body. See the Chapter of *water*, as an element or instrument.

Of all these principles, the *sulphur* is the only active, and vital one ; and that whereon all life and motion depends ; for mercury, *e. gr.* is inert, and never acts, unless when acted on by sulphur or fire : and salts are never dissolved, but by fire alone ; nor does water act but by heat ; without which it would be a fixed mass, or *ice* : and as to earth, no body doubts it merely inert, and inactive. So that all the activity in the fossil or mineral kingdom consists in the sulphur alone : and hence some of the later chymists have denominated sulphur, *active, masculine*, &c. with regard to which the rest are inactive, torpid, feminine, &c. See further in the chapter of *the operations of chemistry*, and that of *fire, water*, &c.

We now proceed to vegetables.



Second

OF VEGETABLES;

OR, THE

VEGETABLE KINGDOM.

Vegetables defined.

A Vegetable is a body generated of the earth, or of something arising of the earth, to which it adheres, or is connected by parts call'd roots, thro' which it receives the matter of its nourishment, and increase; and consists of juices, and vessels, sensibly distinct from each other: or, a vegetable is an organical body, composed of vessels, and juices every where distinguishable from each other; to which body grow roots, or parts whereby it adheres to some other body, from which it derives the matter of its life, and growth.

Distinguish'd from fossils and animals.

This definition furnishes a just and adequate idea of a vegetable: for by its consisting of vessels and juices, it is distinguished from a fossil; and by its adhering to another body, and deriving its nourishment therefrom, it is distinguish'd from an animal*.

A vegetable is defined an organical body, because consisting of different parts, which jointly concur to the exercise of the same function: *adhering by some of its parts to another body*; for we know of no plant that is absolutely vague and fluctuating, but has still a body it adheres to: tho' that body may be various, *e. gr. earth*, as in our common plants; *stone*, as in rock-plants; *water*, as in the sea-plants; and *air*, as in some mucilages.

* Few authors but observe the near analogy between the vegetable and animal oeconomy and structure. M. Reneaume, from a survey of plants, concludes, 1^o, That the *root* in plants, does the office of the parts contained in the belly of animals destined for nutrition; it being this chiefly that prepares, digests, alters, and changes the food into a nutritious juice, to be afterwards distributed to all parts. 2^o, That the *trunk*, and *branches* of trees, bear some relation to the exterior members or limbs of an animal, which it may indeed subsist without, tho' their rotting, and mortification, does frequently occasion a total destruction thereof. 3^o, That 'tis with good rea-

son that countrymen, in pruning, and lopping trees which they would have grow again, cover the wounds, and the remains of the stumps, with earth or clay, to prevent an *extravasation*, which would drain 'em of all their vital moisture. And hence, likewise, it is, that when the branch of a tree is broke, without the bark's being entirely separated, if the pieces be set again, and the *fracture* tied with a bandage, capable of retaining the sap, and excluding the access of the air, the branch will heal again, a *callus* be form'd, &c. just as in a fractur'd bone. *Mem. de l'Acad. An. 1707.*

As to those few plants which appear to float with the water, their manner of growth is somewhat anomalous *. *M. Tournefort* has shewn that all plants do not arise, strictly, from seeds, but that some instead of semen, deposite, or let fall a little drop of juice, which sinking in the water, by its gravity, reaches the bottom, or some rock, &c. in its way; to which it sticks, strikes root, and shoots into branches; such is the origin of coral †, which by distillation yields a volatile salt.

Add, that the root of a plant may have any situation at pleasure, with respect to the body thereof; nor needs it either be lowest or highest, &c. Accordingly in aloes, coral, mosses, fungus's, &c. the root is frequently uppermost, and its growth downward ‖.

The vessels, or containing parts of vegetables, consist of mere earth, bound, or connected together by oil, as a gluten; which being exhausted by fire, air, age, or the like, the plant moulders, or returns again into its earth, or dust: thus in vegetables burnt by the intensest fire, the

* There are some species of sea-mushrooms, particularly the *neptune's-cap*, which are not found to adhere to any body: but *M. Tournefort* observes, they have been sometimes observ'd with a little pedicle, which might have sustained them. And hence he infers, that they originally grew to the bottom, and had their generation like the rest. He adds, however, that when they have lost their pedicle, 'tis probable they are fed by some juice, which the sea-water lets insinuate thro' the pores of their surface. *Mem. de l'Acad. An. 1700.*

† Coral has been suspected by the naturalists of all ages for a sea-plant; but the moderns have demonstrated it such; and even discovered its flowers and seeds. That illustrious naturalist the Count de *Marigli*, having long doubted the vegetable nature of coral, was at length convinced by the following experiment: having steep'd some coral, fresh gather'd, in seawater; he perceived, in a short time, that the little ruddy tubercles which appeared on the surface of its bark, began gradually to unfold; and at length opened into white flowers, in the form of stars of eight points, which were sustain'd by a little calx divided in like manner into eight parts. Upon taking the coral out of water, the flowers immediately closed, and return'd into red tubercles as before; which tubercles being closely squeezed, yielded a sort of milky juice. And upon returning the coral into the water, as before, the tubercles, in an hours time, o-

pened, or flower'd a-fresh: And this was continu'd for 6 or 8 days, when the buds or tubercles ceas'd to blow any more. In 10 or 12 days they became detach'd from the coral, and sunk to the bottom, in form of little yellow balls. These tubercles, then, according to the analogy of plants, should be the flowers of coral; and the milky viscid juice, contain'd therein, the semen; accordingly 'tis held, that when this juice falls on a properly disposed subject, or nidus, a new coral arises therefrom.

Add, that the analysis of coral, answers precisely to that of other sea-plants, all of 'em affording a volatile urinous salt, and a thick blackish, fetid oil. *Mem. de l'Acad. An. 1708.*

There are corals of divers colours; the most usual, and valuable, are red, and white; others are feuilemorr, carnation, green, yellow, ash-colour'd, &c. *Journ. des Scavans, An. 1710.*

‖ The vascular structure of vegetables is rendered very apparent by an experiment of Mr. *Willoughby*; cutting off some pretty big branches of birch, and making a sort of basin or reservoir, on the end thereof with soft wax; upon filling this with water, and holding the branch upright, the water, in a few minutes, sunk into the vessels of the wood, and running quite thro' the length, dropt out of the end considerably fast; continuing so to do, so long as water was pour'd on. The same succeeds in sycamore, walnut, &c. tho' the flux here is not so copious. *Phil. Transact. N° 70.*
earth.

Indissoluble by fire. earth or matter of vessels is left entire, and undissoluble by its utmost force; and consequently, the matter thereof is neither water, nor air, nor salt, nor sulphur, but earth alone.

Absorbent vessels of plants. The root or part, whereby vegetables are connected to their matrix, and by which they receive their nutritious juice, consists of an infinite number of *vasa absorbentia*, which being dispers'd thro' the interstices of the earth, attract and imbibe the juices of the same*; consequently every thing in the earth, that is dissoluble in water, is liable to be imbibed; as air, salt, oil, fumes of minerals, metal, &c. and of these do plants really consist.

These juices are drawn from the earth, very crude; but by the structure and fabric of the plant, and the various vessels they are strained thro', become changed, further elaborated, secreted and assimilated to the substance of the plant.

The motion of the nutritious juices of vegetables is produced, much like that of blood in animals, by the action of the air; in effect, there is something equivalent to respiration throughout the whole plant.

Arteries, &c. The discovery of this we owe to the admirable *Malpighi*, who first observ'd that vegetables consist of two series's or orders of vessels; 1^o, Such as receive and convey the alimental juices, answering to the *arteries, lacteals, veins, &c.* of animals. 2^o, *Trachea* or *air-vessels*, which are long hollow pipes, wherein air is continually received and expelled, *i. e.* inspired and expired; within which *Trachea*, he shews, all the former series's of vessels are contained.

Trachea.

Hence it follows, that the heat of the year, nay, of a day, of a single hour, or minute, must have an effect on the air included in these *Trachea*, *i. e.* must

* The principle, whereby the root imbibes its food, is somewhat controverted: some will have it effected by means of the pressure of the atmosphere, in the same manner as water is raised in pumps: But this is precarious; as being founded on the supposition that the absorbent tubercles are void of air: beside that the atmosphere could only raise the juice 32 foot high, whereas there are trees much higher. Others have recourse to the principle of attraction, and suppose the power that raises the sap in vegetables, to be the same with that whereby water ascends in capillary tubes, or in heaps of sand, ashes, or the like: But neither will this alone suffice to raise water to the tops of trees. One would suspect, therefore, that the first reception of the food, and its propagation, thro' the body, were effected by different means; which is confirm'd by the analogy of animals.

Some of our ablest naturalists hold water the only nutritious matter of vegetables: *Helmont* and *Mr. Boyle* give us some experiments which very much favour this doctrine. The first, weighing a quantity of earth, and planting a willow therein, which he water'd with rain, or distill'd water only; in 5 years time raised it from 5 pound weight, to 169 pounds 3 ounces; and this without any greater diminution of earth than 2 ounces: and *Mr. Boyle* found the like experiment to succeed with squash seed. *Dr. Woodward*, on the other hand, has some curious experiments, which seem to overturn this notion, and to prove that mere elementary water is not proper food for vegetables; the water, according to him, only the vehicle of the alimentary matter, the earth contain'd therein, supplying all the vegetation. See the *Article of Water*.

rarify

rarify it, and consequently dilate the *Trachea*: whence arises a perpetual spring or source of action to promote the circulation in plants.

For by the expansion of the *Trachea*, the vessels containing the juices, ^{Effect of heat thereon.} are pressed; and by that means the juice contained is continually propelled, and so accelerated. By which propulsion, the juice is continually comminuted, and rendered more and more subtiler, and so enabled to enter vessels still finer and finer*; the thickest part of it being, at the same time, secreted, and deposited into the lateral cells or *loculi* of the bark, to defend the plant from cold, and other external injuries.

The juice having thus gone its stage from the root to the remote ^{Circulation of the sap.} branches, and even the flower; and having, in every part of its progress, deposited something, both for aliment, and defence; what is redundant, passes out into the bark, the vessels whereof are insculcated with those wherein the sap mounted; and thro' these it redescends to the root, and thence to the earth again. And thus a circulation is effected†.

* But there may seem somewhat of difficulty behind; viz. why the pressure and contraction of the air, in the *Trachea*, should determine the juice upwards, rather than in any other direction? To which it may be answered, that the heat being greater toward the root, than the top; the air is more rarified, and consequently the compression the juices undergo, is greater, in the former place than the latter; so that they must be determined that way, for the same reason as the moisture of green wood, when burning, exudes thro' the part furthest from the fire.

† The notion of the sap's circulating, was entertain'd by several authors, much about the same time; without any communication from one to another; particularly M. Major, a physician of *Hambourg*, M. Perrault, Mariotte, and Malpighi. It has met, however, with some considerable opposers; particularly the excellent M. Dodart, who could never be reconciled to it.

One of the great arguments for it, is, that the same experiments of ligature and incision which evince a circulation of the blood in animals, succeed, in the like manner, in plants; particularly in such as abound with sap, as the great tithymale, milk-thistle, &c. For a metalline girt being here fix'd tight round the stem; the part above it is found to swell very considerably, and that below it a little. Whence it appears, that there is a juice

ascending from the root, and likewise another descending from the branches; and that the latter is thicker than the former; which quadrates exactly with the common system; the juice being supposed to arise in capillary vessels, in form of a subtle vapour, which condensed in the extremes of the plant, by the neighbourhood of the cold air, turns back, in form of a liquor, thro' the more patent pipes of the inner bark.

M. Dodart, instead of the same juice's going and returning; contends for two several juices; the one, imbibed from the soil, digested in the root, and thence transmitted to the extremes of the branches, for the nourishing of the plant; the other, received from the moisture of the air, in at the extremities of the branches: so that the ascending and descending juices are not the same. One of his chief arguments, is, that if two trees of the same kind be transplanted in one day, after first cutting off their roots, and branches; and if after they have taken root again, some of the new shoots, put forth each year, be cut off one of them, it will not thrive half so well, notwithstanding its root and trunk's being entire, as the other. This he conceives to be a proof of the plant's deriving nourishment by the branches; and concludes it to be of an aerial nature, because form'd of the moisture of the air, dew, &c. whereas that imbibed from the soil, is terrestrial, &c. *Hist. de l'Acad. Roy. An. 1709.*

Functions of
night and day.

Thus is every vegetable acted on by heat or cold, during the day-time; especially while the sun's force is considerable; the sap-vessels squeezed, and pressed, and the sap protruded, and raised, and at length evacuated, and the vessels exhausted: And in the night again, the same *Tracheæ* being contracted by the cold of the air, the other vessels are eased, and relaxed, and so disposed to receive fresh food for the next day's digestion, and excretion. And thus plants may be said to eat and drink in the night-time.

But what seems to be an *experimentum crucis*, and to decide the controversy in favour of a circulation, is the following experiment of the reverend Mr. *Lawrence*: On a branch of plain jessamin, whose stem spreads into two or three branches, inoculate a bud of the yellow-striped jessamin; and as the tree comes to shoot, the following spring, some of the leaves will be found ringed here and there with yellow; and this even on the other branches not inoculated; till, by degrees, the whole tree, even the very wood of the young shoots, appear all variegated, or striped green and yellow.

* What course the juice takes after it is imbibed by the roots, is not very clear; the vessels that take it up to convey it thro' the plant, are too fine to be traced: and hence it has been contraverted, whether it is by the *bark*, or the *pith*, or the woody part, that the plant is fed.

Some contend for the *wood*, which they observe to consist of slender capillary tubes, running parallel to each other from the root up the trunk, proper to receive in a fine vapour; in the ascent whereof, the fibres become opened, and their substance increased. And thus it is, that the trunks of trees increase in circumference, by *ingestion*.

The more common opinion is for the *bark*; the juice raised by the capillaries of the wood, is here supposed to descend by the larger fibres placed in the inmost part of the bark, immediately over the wood; in which descent, the sap, now sufficiently prepared, adds a part of its substance to the contiguous wood; and thus increases by *apposition*. And hence it is, that hollow, carious trees, which have neither pith, nor wood, except just enough to sustain the bark, do grow, and bear.

What confirms this, is an observation of Dr. *Tonge*, communicated to him by an eminent planter in *Glocestershire*; viz. that by binding a tree round about very closely, and strongly, with cords, so as to intercept what rises betwixt the bark and the wood, the blossoming, and bearing of the tree is retarded: And by such means, in some years, when the open weather bringing on too early a spring, endangers the destruction of the blossoms, &c. he has often prevented a scarcity of forward fruits, which are usually nipped by the late frosts. *Phil. Transact.* N° 68.

Add, that in the journals of the royal society, Dr. *Beal* assures us from his own experiment, that if a circle be drawn round a common *English* tree by incision to the solid timber; how thin soever the knife be, and tho' nothing at all be taken away; the tree will die from that part upwards: only the part below the cleft will grow on, and prosper, notwithstanding the incision. He adds, that he has seen some old huge ashes, which had been bared of their bark by the deer, from the root to the height of four feet quite round; and yet have continued their growth for many years; and some bark, which was left in some few places, no broader than an hand, had a fresh verdure more lovely than any other part of the tree. *Philos. Transact.* N° 46.

To this others object, that there have been trees known to grow, and put forth leaves and flowers for several years, without any bark; particularly that elm in the *Tuilleries*, whereof an account was given to the royal academy, by Monsieur *Parent*. Add, that the plantane and cork-tree cast their barks, and get new ones, as serpents cast their skins; and 'tis hard to conceive how the bark, during such transition, should contribute to the support of the plant.

The humour or sap of a plant, then, is a juice furnished by the earth, ^{Ingredients of the sap.} and changed into the plant; consisting of some fossil parts, other parts derived from the air, and rain; and others from putrified animals, plants, &c. consequently, in vegetables are contained all kind of salts, oil, water, earth; and, probably, all kinds of metals too, inasmuch as the ashes of vegetables always yield somewhat which the load-stone attracts.

plant. Beside, in some plants, as the vine, elder, &c. the bark is very inconsiderable, but the pith very copious; which should seem to intimate, that they are fed by the latter rather than the former. And it is further observable, that in proportion as they grow old, the pith becomes fibrous, and woody; which shews, that the pith is disposed by nature to form woody fibres; and therefore may be proper to furnish wood with its nutritious juice.

Lastly, it is observed, that if you cut off a ring of bark around a tree, three or four inches broad, parallel to the horizon; and thus lay the wood quite bare, so that the tree cannot receive any nourishment by the bark; yet will it not lose its leaves; nay, it will bear flowers and fruit the same year, and this double its usual crop: tho' in the succeeding winter, all the branches above the incision will die. Hence, M. Parent argues, that the juices which produce and nourish the leaves, the flowers, and fruit, do not ascend by the bark, but by the pith; but those which nourish the wood and bark, by the bark: and that the quantity of the juice which should naturally have pass'd by the pith, having been augmented with that which should have pass'd by the bark, is the cause of the extraordinary produce of fruits and flowers. In effect, says M. Fontenelle, the pith of plants, like the medulla in animals, is a collection of an immense number of little vesicles, which seem destin'd to filtre and elaborate a finer juice than should seem necessary for the nutrition of mere wood. *Hist. de l'Acad. An. 1709.*

In answer to all this, the retainers to the bark alledge, that the parts of a tree disjoined from their whole, may take with them a stock of nutritious juice sufficient to make them vegetate. Thus, the branches of elder, willow, &c. cut from the stock, will shoot forth leaves, twigs,

&c. without being ever put in the ground; and pieces of wood, half dry, have been known to do the same: which must be owing to some remaining juice agitated and subtilized to a certain degree by the warmth and action of the air. And if parts thus cut off may vegetate; much more may those which still adhere to the tree, which can scarce ever be entirely deprived of new juices; since, tho' the bark should not furnish them any, yet they will receive some from the *bleu*, or that part of the wood which was last form'd, and has not altogether lost its cortical nature. This accounts for the phenomena of the elm in the *Tuilleries*, the ash's of Dr. Tange, and the olive-trees of M. Magnol; excepting that in this last instance, the vegetation is more abundant, after taking away the bark, than before; which gives a new difficulty.

To solve this, M. Reneaume observes, that the buds out of which flowers and fruits arise, are form'd at the same time as the young branches whereon they grow; for old wood never bears any: that the buttons wherein these fruit-buds are contained, are easily distinguished from the buds that yield nothing but wood: that these fruit-buds require nothing but to be expanded, which sometimes does not happen, in perfection, till the second year: that it is easily possible this expansion should not succeed so well, when, beside a competent stock of juice, in reserve, new juices are brought by the bark, in too great plenty to be sufficiently attenuated, and subtilized, for entering the minute vesicles of the forming part. Thus, by cutting off the communication of new juices by removing some of the bark, the juice is disposed to insinuate more readily into the little vessels; and thus to give rise to a greater number of flowers and fruits.

As to the elms of *Luxembourg*, M. Reneaume examined them himself, and found they were not so naked, but that there

Gradual progress
and preparation
of the sap.

This juice enters the plant in form of a fine and subtile water; which, the nearer it is to the *root*, the more it retains of its proper nature; and the further from the root, the more action it has sustained, and the nearer it approaches to the nature of the vegetable.

Consequently, when the juice enters the root (the bark whereof is furnished with excretory vessels, fitted to discharge the excrementitious part) it is earthy, watery, poor, acid, and scarce oleaginous at all.

In the trunk
and branches.

In the *trunk* and *branches* it is further prepared, tho' it still continues acid; as we see by the tapping or perforating of a tree in the month of *February*, when it distils a watery juice apparently acid.

In the buds.

In the leaves.

The juice being hence carried to the *gums* or *buds*, is more concocted; and here having unfolded the leaves, these come to serve as lungs for the circulation, and further preparation of the juice.

For those tender leaves being exposed to the alternate action of heat and cold, moist nights, and hot scorching days, are alternately expanded and contracted; and the more, on account of their reticular texture.

In the petala.

By such means is the juice still further alter'd, and digested; as it is further yet, in the *petala* or leaves of the flowers, which transmit the juice, now brought to a further subtilty, to the *stamina*: These

were some remains of the inner rind or *blea*, whereby the juice might mount: And the same, doubtless, was the case of the ashes mention'd by Dr. *Tonge*. Add, that M. *Maraldi* observed to the royal academy, that a shoot of a plum-tree having been broke, so as only to hang by a piece of bark; yet, upon raising and setting the fractured parts, it produced wood, flowers, and fruit.

From the same observation of the elm of *Luxembourg*, M. *Reneaume* even draws a conclusion in behalf of his system, viz. that it is the bark forms the *blea* or *bleak*; and that as the *blea* is the wood last form'd, all the wood comes from the bark.

The bark, *liber*, is to be conceived as consisting of a number of cylindric and concentric surfaces, whose texture is reticular, and in some trees apparently extensible every way, by reason the fibres thereof are soft and flexible. While in this condition, they are either hollow, and so real canals; or, if they be solid, their interstices are canals. The nutritious juice which they are continually receiving, and which, part of it, is detain'd in them, makes them grow both in length and thickness, strengthens, and brings them nearer each other. Perhaps the longitudinal fibres may grow the fastest. By such means, the texture, which before

was reticular, becomes an assemblage of strait fibres, ranged vertically, and parallel one behind another; i. e. it becomes a new woody substance, under the name of *blea*.

While the *blea* remains, any thing soft, and retains somewhat of the nature of a bark; it may maintain a feeble vegetation: but when it is grown absolutely hard and woody, it can no longer contribute thereto. The vegetation of young branches is the most lively and vigorous, and the only one that goes as far as the flowers and fruits, by reason they are little else but bark.

For the *pith*; as the woody substance of the trunk becomes more woody, the *pith* is compressed and straiten'd, to such degree, that in some trees it quite disappears: Whence it appears, that its office in vegetation is not very important, since its use is not perpetual. By its spongy structure, it should seem fitted to receive any superfluous moisture transuding thro' the pores of the woody fibres: And if by the excess of such moisture, or the like cause, it corrupt and rot, as frequently happens in elms, the tree does not grow the worse for it. A convincing proof, it is of no great use. See the *Hist. de l'Acad. R. des Sciences*, An. 1711.

communicate it to the *farina*, or dust in the *apices*, which is, as it were, ^{In the stamina, farina, &c.} the male seed of the plant; where having undergone a further maturation, it is shed into the *pistil*, which performs the office of a womb or *uterus*: and thus having acquired its last perfection, it gives rise to a new ^{Generation of plants.} fruit or plant*.

Six

* The generation of plants bears a near analogy to that of some animals, particularly such as want local motion; as muscles, and other immoveable shell-fish, which are hermaphrodites, and have the genital organs of either sex.

The flower, for all its finery, has been allow'd for the *puerum* of a plant: but the design of so much mechanism, and so many parts, was but little understood: To instance in a *tulip*; its flower consists of six leaves, in the middle whereof arises the *pistil*, and around that are ranged a number of little threads, which terminate a-top in little bunches replete with a fine powder. This is the general structure of flowers; tho' we find it diversify'd a thousand ways, some species appearing to want one part, and some another, and some even the whole flower.

The dust contained in the *apices*, M. *Tournefort* took to be only a sort of excrement, remaining of the food of the fruit; and the *stamina* to be no other than excretory ducts. But M. *Morland*, M. *Geoffroy*, and other of the later authors, are agreed on assigning them nobler uses. On their principle, the *stamina*, with the *apices* and *farina*, make the male part of the plant; and the *pistil* the female.

At the bottom of the *pistil* of the lilly, Mr. *Bradley* observes a vessel, which he denominates in a particular manner the *uterus* or womb: it contains three ovaries, which are fill'd with little eggs, or rudiments of fruit, like those found in the *ovaria* of animals; and which, he adds, always decay, and come to nothing, unless impregnated with the *farina* of the same plant, or some other of the same kind. The *stamina*, according to him, serve for the conveyance, or perhaps the secretion of the male sperm, to be perfected in the *apices*, which answer to the *vesiculae seminales*; whence, being emitted into the orifice of the *pistil*, it is either conveyed thence into the *utricule*, to fecundify the female *ova*; or it is lodg'd in the *pistil*,

and by some magnetic power draws the nourishment from other parts of the plant into the embryo's of the fruit; and thus makes them swell, grow, &c.

Accordingly, the disposition of the *pistil*, and *apices* about it, is always such, as that the *farina* may fall on its orifice: 'tis usually lower than the *apices*; and when we perceive it grown higher, we may conclude the fruit has begun to form itself, and has no further occasion for the male dust. Add, that as soon as the affair of generation is over, the male parts, together with the leaves, fall off; the rest of the work being left to the female: and at the same time, the *pistil*, or neck of the *uterus*, begins to contract itself. Nor must it be omitted, that the top of the *pistil* is always either cover'd with a kind of velvet-facing, or emits a gummy juice, the better to catch and retain the dust of the *apices*. In flowers that turn downward, the *pistil* reaches much lower than the *stamina*, that the dust may fall in sufficient quantity from their *apices*, for the business of impregnation.

This system of vegetable generation favours much of that admirable uniformity every where observ'd in the works of nature: but 'tis experience alone must determine for it. Accordingly, M. *Geoffroy* assures us, that in all the observations he had made, the cutting off the *pistil*, before it could be impregnated by the *farina*, actually render'd the plant barren for that season; and the fruits abortive: And the like has been observ'd by Mr. *Bradley*, and others.

In many kinds of plants, as the oak, pine, willow, &c. the flowers are sterile, and grow separate from the fruit: but these flowers, M. *Geoffroy* observes, have their *stamina* and *apices*, whose *farina* may easily impregnate the rudiments of the fruit, which are not far off.

Indeed, there is some difficulty in reconciling this system with a certain species of plants which bear flowers without fruit; and another species of the same kind

Six classes of juices in plants.

Nutritious juice
of the root and
stem.

THE first class comprehends the crude, *nutritious juice*, or the juices of the root and stem of plants; which are little more than the mere matter of the element as drawn by the root * from the body it adheres to, whether it be earth, water, or the like.

This

kind and denomination, which bear fruit without flowers: such are the palm, hemp, hop, poplar, &c. which are hence distinguished into *male* and *female*. For how should the *farina* of the male here come to impregnate the *ova* of the female? This difficulty M. Geoffroy solves, by supposing the wind to be the vehicle that conveys the male dust to the female *uterus*: which is confirm'd by an instance from Jovianus Pontanus, of a single female palm-tree growing in a forest, which never bore fruit; till having risen above the other trees of the forest, and being then in a condition to receive the *farina* of the male by the wind, it began to bear fruit in abundance.

For the manner wherein the male dust fecundifies the *ova*, M. Geoffroy advances two opinions; corresponding to the two systems of animal generation: The first, that the *farina* being always very sulphurous, and consisting of subtile penetrative parts, when it falls on the pistil, resolves; and its more active parts penetrating into the ovary, and *ova*, excite a fermentation, which putting the latent juices of the young fruit in motion, occasions the parts to unfold. In this hypothesis the grain or ovum is supposed to contain the plant in miniature; and only to want a proper juice to put it upon expanding.

In the second, the *farina* of the male plant is supposed to be the first germ or *semen* of the new plant; and that it needs nothing to enable it to unfold and grow, but a suitable *nidus*, with proper food, which it finds prepared in the ovary.

This latter opinion seems more agreeable to observation; for the little embryo's of the ovary, viewed with the best microscopes, don't discover the least appearance of a bud before the *apices* have shed their seed. In leguminous plants, if the *petala* and *stamina* be removed, and

the pistil, or part which becomes the pod, be viewed with a microscope, e'er yet the flower be blown; the little, green, transparent *vesicula*, which are to become the grains, will appear in their natural order, but without showing any thing else beside the mere coat or skin of the grain. If the same observation be continued for several days successively in other flowers, as they advance, the *vesicula* will be found to swell, and by degrees to become replete with a limpid liquor, wherein, when the *farina* comes to be shed, will appear a little greenish speck or globule, floating about at liberty. This corpuscle at first shews no signs of organization; but, in process of time, as it grows in bulk, we begin to distinguish two little leaves or horns: The liquor wastes insensibly, as the corpuscle grows, till, at length, the whole grain becomes solid and opaque; and then, upon opening it, we find its cavity fill'd with a young plant in miniature, and easily discern a *plumula*, or future stem; a *radicle*, or root; and the *lobes* of the bean or pea.

It may be added, that the *vesicula*, or grains, have little apertures which correspond to that of the pistil, by means whereof the small particles of the *farina* will find an easy passage into the embryo of the grain. To this aperture or *cicatricula*, the radicle, when form'd, corresponds; and through it, it passes, when the grain comes to germinate. See the *Memoirs de l'Acad. An. 1711*.

* If no rain, or other moisture, says Dr. Tonge, come at the roots of trees, they will not grow; but if only the tips or points of the roots be water'd, tho' all the rest remain dry, they will grow very well. For the points of the roots shoot out yearly a sharp-pointed tender part, something like the sharp bud at the end of

This juice is found in every part of the plant; and therefore may be held an *universal* juice; yet we do consider it as the juice of the *root* and *stem*, because it is chiefly found therein.

By what we have been able to observe, it is a subacid watery lymph, ^{its qualities.} without any specific taste, or smell as not being yet arrived to the maturity of oiliness.

To this class belong those juices which distil in great abundance from wounds or incisions made in the woody parts of plants †: such, *e. gr.* is that tart liquor oozing from the root of the *walnut-tree*, when cut ^{In the walnut-tree.} off in the month of *May*; and which is found an excellent remedy against the epilepsy.

Such also is that limpid subacid humour flowing out very plentifully at an incision in the *birch-tree*, in the month of *March*, to the value of several gallons in a few days. It's a good diuretic, and commended by *Helmont* against the stone and gravel ‖.

Such,

of a sprig; by which the root not only enlarges itself in the earth, as the branches do in the air; but also receives its nourishment; and that tender part is naturally moved towards the best-moistened and tenderest earth. *Phil. Transact.* N^o 44.

† From the latter end of *January* to the middle of *May*, trees will bleed: those that are said to run first, are the poplar, asp, abele, maple, sycamore; some, as willows, and the birch, are best to tap about the middle of the season; and the walnut toward the latter end of *March*. They generally bleed a full month in the whole. The best time of the day for tapping, is about noon. The sycamore will run in hard frost, when the sap freezes as it drops. When a large walnut would run no longer in the body or branches, it would run at the roots, and that longer on the south or sunny side, than on the north or shady side. *Dr. Tonge*, in *Philos. Transact.* N^o 43, &c.

To obtain the greatest store of sap in the shortest time from the body of a tree, bore it quite thro' the pith, and the very inner rind on the other side, leaving only the bark unpierced, on the north-east side: this hole to be made sloping upward, with a large augre, and that under a large arm near the ground. This way, the tree will in a short time afford liquor enough to brew with: and with some of these sweet saps one bushel of malt will make as good ale as four bushels with ordinary

water. Sycamore, I take to yield the best brewing-sap, being very sweet and wholesome. *Id. Ibid.*

‖ The bleeding of the birch has afforded naturalists matter of much speculation. *Willoughby*, *Ray*, *Lister*, &c. have made a great number of experiments and observations thereon, which may let some light into the business of vegetation in general.

—In the birch, the sap issues out at the least twigs of branches, and the smallest fibres of roots, in proportion to their bigness; the gravity always promoting the discharge: so that a branch or root which bends downward, will yield much more juice than another of the same size, erect. —Branches, and young trees cut quite away, and held perpendicularly, will bleed; and if the tops be cut off, and inverted, they will bleed also at the little end. —In birches, no sap issues out at the bark, be it ever so thick; but as soon as the bark is cut quite thro', they then first begin to bleed: the bark being quite off for an hand's breadth round, abates the bleeding of the tree above the pared place. —A wound made before the sap rises, will bleed when it does rise.

The changes of weather have a great effect on the bleeding of plants; insomuch that *Dr. Tonge* is of opinion, could we but observe it to advantage, we should hence have much better indications of the alterations of weather, in respect of heat, cold, moisture, &c. than from any weather-

The vine.

Such, lastly, is the juice issuing out of the vine, wounded in the spring-time, which always tastes tartish, and ferments like the grapes themselves; being held an aperitive and laxative*.

This juice of the fossil kind.

This juice may be esteemed as yet fossil being generated of, and in the earth: for the juice of the earth being received into the canals of the plant, retains its nature during two or three circulations; nor does immediately commence a vegetable juice. As is the case, likewise, in animals; the foods taken in by which, cannot be immediately converted into the animal nature; but require a stated time, and a certain number of circulations, concoctions, &c.

The chyle of plants.

This class of juices, therefore, we look upon as the *chyle of the plant*; being chiefly found in the first order of vessels, viz. in the roots, and the body of the plant, which answer to the stomach, and intestines of an animal.

The first humour of vegetables, therefore, is supplied from the earth: but in the surface of the earth, which is the part plants adhere to, are found bodies of all the three kinds: viz. *fossil* bodies, and putrified parts of

ther-glasses. When the weather changes from warm to cold, the birches cease to bleed; and upon the next warmth, begin again: But, which is very remarkable, the contrary always obtains in the walnut-tree, and frequently in the sycamore, which, upon a fit of cold, will bleed plentifully, and as that remits, stop: A morning-sun after a frost will make the whole bleeding tribe bleed afresh.

Lastly, a culinary fire will have the like, or greater effect than the sun, and immediately set them a bleeding in the severest weather. Branches of maple and willow, cut off at both ends, will bleed, and cease at pleasure, again and again, as you approach them to, or withdraw them from the fire; provided you balance them in the hand, and often invert them, to prevent the falling, and expence of the sap: yet, being often heated, they will at length quite cease, tho' no sap was at any time sensibly lost: and when they have given over bleeding, by being brought within the warmth of the fire, the bark will be found very full of juice.

A hard ligature, made within a quarter of an inch of the end of a wood-bine branch, Dr. Lister assures us, did not hinder its bleeding at all, when brought within the warmth of the fire.—Maple and willow-branches, quite bared of bark, and brought to the fire, shew no moisture

at all. The same, half bared of bark, would bleed only from those half of the circles cover'd with bark. A branch of ivy, of itself, bled a liquid yellowish resin from the bark, and near the pith; but, when brought to the fire-side, bled a thin, dilute, colourless sap, from the intermediate wood-circles. One, or both ends of the pith of a willow being sealed up with hard wax, it will yet bleed freely by the fire.—Branches of willow cut off in a very severe frosty morning, and brought within the air of the fire, would shew no moisture at all; no, not when held till warm, and often and long turn'd: yet the same branches, after lying all night on a grass-plot, did, next morning, when the frost was broke, freely bleed.—Lastly, a twig of maple, whose top had been cut off before, and had then bled; being now taken off from the tree, and brought within the air of the fire, and held with the formerly cut end downwards, would not run at all; but with the other end down, run apace. *Philos. Transact.* No 48, 57, 58, 68.

* The French ladies use it to take away freckles; beside which, M. Reneaume intimates another use it is applied to, of a quite different kind; viz. miracles. It seems, most of the miraculous tears, let fall by saints, madona's, &c. are drops of this liquor. *Mem. de l'Acad. An. 1707.*

animals,

animals and vegetables. Consequently this prime, radical juice of vegetables is a compound from all the three kingdoms.

II^d Class of juices is that of the *leaves*. The leaves, we have already observed, are the real lungs of the plant; and accordingly make a further change of the juice which they receive from the roots, and stem, by force of the air *. The juice of the leaves, therefore, is different from the first juice; as being more sulphurous, and further elaborated: not that it derives any sulphur from the sun; but that its watery part exhaling, it becomes more oily and less volatile. *Juices of the leaves.*

The juice of the leaves is of three kinds.

The first is the *nutritious juice* of the leaves; which is that already described; only further elaborated in the minute *vesicula* of the leaves, and consequently less acid, and watery, and more oily, and saccharine.

This is that juice drawn out of the leaves, by expression. *Note*, The leaves of all plants are of different tastes, from the differences in the oil of this juice: that taken away, the taste is the same in all. The oil, therefore, is their distinguishing character.

The second is *wax*; which exuding † out of the leaves, adheres to their surface, and is scrap'd off by the bees, with their rough thighs, to build their combs withal. This is chiefly afforded by lavender, and rosemary: from which last, I my self have sometimes been able to gather wax; and by the assistance of the microscope, any body may plainly perceive the wax sticking on the leaves of that plant. Tho' some have mistakenly imagin'd that it was from the testicles, or *apices* of the stamina of the flower; and others from the *petala*, or leaves of the flower, that wax was gathered. *Wax.*

Wax therefore is a vegetable, not an animal matter: and hence it is that *Hungary water*, in which lavender is a main ingredient, is frequently found to have somewhat of a waxy smell **.

The third is *manna*; not that wherewith the *Israelites* were fed in the desert, but a drug, sold among us as an emollient, laxative medicine.

Manna is an essential, saccharine salt, exuding, chiefly, by night, and *Manna.* in the summer season, from the leaves of a sort of ash, growing in *Cal-*

* The great importance of the leaves to the fruit, appears from common observation, viz. that when the caterpillars seize on a tree in the fruit-season, they only feed on, and destroy the leaves; and yet the consequence hereof is, that the tree shall frequently appear as if dead, and the fruit prove abortive. *Mem. de l'Acad. An. 1707.*

† Plants, like animals, have both a sensible, and insensible perspiration; and when either of 'em is too copious, it frequently proves mortal. And thus it is, according to M. *Rereau*, that the wal-

nut-trees of *Dauphiné* usually die, after a too profuse load of a sort of manna which they yield. *Mem. de l'Acad. An. 1703.*

** To procure the wax from the combs, for use: the honey being separated from them, they put all that remains in a large cauldron, with a sufficient quantity of water; and thus, by means of a moderate fire, melt it. This done, they strain the water, &c. off, thro' a cloth in a press. Before it grows cold, they scum it well, and cast it into moulds.

This is the *yellow wax*, which blanched and purified makes the *white-wax*.

bria and *Sicily*: and adhering thereto in form of a crust, to be gather'd next morning, e'er the sun is up †.

It does not fall as a dew from heaven; nor is it any thing communicated from the air, as many have imagin'd; but is a sweat exhaling from the leaves themselves; as is evident hence, that tho' the leaves be inclosed in a phial, or cover'd up with a cloth, all night; they are still found next morning with their usual load of *manna*.

The like substance is found to exude from the leaves of the linden tree and poplar, in the heats of *May* and *June*, at which time they have a honey-taste, and are even seen with a fatty juice on 'em, which at the approach of the cold evening gathers into grains.

Juices of the
flowers.

III^d Class of juices are those of the *flowers*; or the genital parts of plants. In these are,

Volatile oil.

First, a pure, elaborated, *volatile oil* or *spirit*, wherein the particular smell of the plant or flower resides; and which, by reason of its extreme volatility, exhales spontaneously; insomuch that if the flower be laid for some time in a warm place, the odorous juice or spirit will be all fled.

This oil, or vapour, is supposed to be the genial, or seminal *Aura* of the plant; or the vehicle of the embryo: consequently, all that we so much admire in the scent of flowers, is the spermatic vapour. If the whole plant be bruise'd, or rub'd together; this odorous spirit becomes so mix'd, or confounded with the other juices, as to remain imperceptible. And hence the juice expressed from roses becomes of a very disagreeable smell, tho' the spirit exhaling from the flower entire, be highly grateful.

Expressed juice.

The second is the juice *expressed* from the flower; which, in reality, is the same with that of the root, and leaves, only further prepared. It is thicker than the former, and has scarce any smell at all. Thus, if you bruise a hyacinth, or other fragrant flower, and express the juice, it will be found altogether inodorous.

Honey.

The third is the sweet juice call'd *honey*, which exudes from all flowers; aloes, colocynthis, and other bitter flowers not excepted.

In all male flowers, that have utricles at the bottom of the petala, is found a viscid, ruddy, sweet juice, in some plenty; and accordingly we see the children gather cowslips, fox-gloves, honey-suckles, &c. and suck the honey from 'em. The bees, too, visit these flowers; and putting in their proboscides, or trunks, suck out the honey, and load their stomachs there-

† Besides this species, which the *Italians* call *Manna di corpo*, they have two other sorts of manna; one procured, as it were, by violence, and by making incisions, which they call *Manna forzata*, or *forzatella*; and another issuing out at the nervous parts of the leaves, in grains as big as wheat, call'd *Manna di fronda*. There are also liquid manna's, brought from *Persia*, *Egypt*, &c. but they are little known or used among us.

with,

with, to be afterwards discharg'd and laid up in their combs : so that honey is a vegetable juice ||.

IVth Class of juices are those of the *fruit and seed* ; the preparation whereof is nature's final work, which perform'd, the plant seems to die, for a time, as all animals are seen to languish after emission of their semen. *Juices of the fruit and seed.*

We always distinguish in plants between *καρπος*, and *σπερμα* seed and fruit; the fruit is the whole external machine, including the seed within it. Thus in an apple, the fruit being that eatable pulp, or parenchyma, in whose centre are 5 or 6 lobules with kernels, or seeds, inclosed therein. This pulp serves to foster, defend and nourish the seed; being, withal, so contriv'd by nature, that when the fruit shall fall to the ground, the pulp may support the seed, during winter, till the approach of the spring afford it proper matter, and food for growing. *Structure of the fruit.*

The juice of the *fruit* is like that of the root, only further elaborated. *Its use.*

The *seed* consists of an embryo, with its coat or cover. The embryo, which contains the whole plant in miniature, and which is call'd the *gem* or *bud*, is rooted in the placenta, or cotyledon, which make the coat or *involucrum*, and serves the same purposes as the *secundines*, i. e. the chorion, and amnios, in animals. *Structure of the seed.*

The placenta, or cotyledon of a plant, is always double; and in the middle, or common centre of the two, is a point or speck, which is the embryo, or *plantule*. This plantule being acted on, and mov'd by the warmth of the sun, and the earth, begins to expand; and protrudes, or shoots out its *radicle*, or root, both upward and downward. By this it absorbs the nutritious juice, from the earth; and so grows and increases; and the requisite heat continuing, the growth continues.

Thus, e. gr. a pea, or bean, being committed to the ground, is, first, found to cleave into two parts; which are, as it were, two leaves, or lobes of

|| Honey was antiently taken for a dew that fell on flowers; but what proves this a mistake, is, that the bees only gather it after the sun is up, when there is no dew left. It must, therefore, either be a liquor prepared in the flower, and excreted by its proper vessels, like manna; or rather the fine dust, or *farina fecundans* of the apices: for according to the observations of M. du Verney, the bees, when in search of honey, fix on no other parts but the *stamina*, and apices, and not on such as yield any liquor.

What is very remarkable, is, that honey, in virtue of its vegetable nature, is discovered, by M. Lemery, to contain iron. Which discovery may, perhaps, serve

as an answer to M. Geoffroy's chemical question, viz. *Whether there is any part of a plant without iron?* For if so delicate an extract from the finest part of the flower, and this further elaborated in the little *viscera* of the insect, be not clear of iron, we may despair of seeing any so. See the *Hist. de l'Acad. An. 1708.*

We have two kinds of Honey, *white* and *yellow*: the white call'd also *virgin honey*, trickles out, spontaneously, from the comb, when inverted, &c. the second is expressed from the combs, in a press, after having first soften'd 'em with a little water, over the fire. There is also an intermediate sort, of a yellowish white colour, drawn by expression, without fire.

the placenta: and in the fissure appears a point which shoots out a root downwards, and a bud upwards; the first spreading it self in the soil to catch the moisture thereof, and the latter emerging into the air, and becoming the stem, or body of the new plant *.

The

* 'Tis very remarkable, how the plumule, or future stem should always get uppermost; and the radicle, or root, be turn'd downwards; and this too, perpendicularly to the horizon: and not only this, but if, by any external means, the stem be diverted from this perpendicularity, and bent, for instance, toward the earth; instead of persevering in that direction, it makes an angle or elbow, and redresses it self.

The same is observ'd in trees, &c. blown down, with their roots, by the wind; or in those planted in pots, upon turning the pot on one side.

Now, the seed from which a plant arises, being the plant it self in little; 'tis easy to suppose, that if it be deposited in the ground, with the plumule perpendicularly upward, and the radicle downward, the disposition should be maintain'd in its future growth. But 'tis known, that seeds sown, either of themselves, or by the help of man, fall at random; and among an infinite number of situations of the plumule, &c. the perpendicular one upwards is but one: so that in all the rest, 'tis necessary the stem and root do each make a bend, to be able, the one to emerge directly upward, the other downward. Now, what force is it effects this change, which is certainly an action of violence?

M. Dodart, who first took notice of the phenomenon, accounts for it, by supposing the fibres of the stem of such a nature, as to contract, and shorten, by the heat of the sun; and lengthen by the moisture of the earth: and on the contrary, the fibres of the root to contract by the moisture of the earth, and lengthen by the heat of the sun. On this principle, when the plantule is inverted, and the root a-top; the fibres of the root being unequally exposed to the moisture, viz. the lower parts more than the upper, the lower will contract more; and this contraction be promoted by the lengthening of the upper, from the action of the sun. The consequence whereof will be, the root's recoiling, infi-

nuating further into the earth, and getting beneath the body of the seed. In a word, the earth draws the root toward it self, and the sun promotes its descent; On the contrary, the sun draws up the plume; and the earth, in some measure, sends it towards the same. *Mem. de l'Acad. An. 1700.*

M. de la Hire accounts for the same perpendicularity, by only conceiving the root to draw a coarser and heavier juice; and the stem a finer, and more volatile one: in the plantule, therefore, we may conceive a point of separation; such, as that all on one side, e. gr. the radical part, is unfolded by the grosser, and all on the other by more subtle juices. If the plantule then be inverted and the root a-top; as it still imbibes the grosser and heavier juices, and the stem the lighter; the point of separation being conceived as the fixed point of a lever, the root must descend, and at the same time, that the volatile juices imbibed by the stem, tend to make it mount. Thus is the little plant turn'd on its fix'd point of separation, till it be perfectly erect. *Mem. de l'Acad.*

The plant thus erected, M. Parent accounts for the stems continuing to rise in the vertical direction, thus: The nutritious juice being arrived at the extreme of a rising stalk, and there fixing into a vegetable substance; the weight of the atmosphere must determine it to fix in a vertical position; so that the stalk will have acquired a new part, perpendicularly over the rest; just as in a candle, which held any how obliquely to the horizon, the flame will still continue vertical, by the pressure of the air. The new drops of juice that succeed, will follow the same direction, and as all together form the stem, that must of course be vertical, unless some particular circumstance intervene.

Add, that whereas the branches are likewise observed, as much as possible, to affect perpendicularity; inasmuch, that tho' they be forced to shoot out of the stems horizontally, yet in their progress, they

The two placentulae, or cotyledones of a seed, are, as it were, a case to this little tender plantule, or point; covering it up, sheltering it from injuries; and feeding it from their own proper substance, which the plantule receives, and draws to it self, by an infinite number of little filaments, or ramifications, call'd *funes umbilicales*, or navel strings, which it sends into the body of the placenta.

Now when the seed is committed to the earth, the placenta still adheres to the embryo for some time, guards it from the access of noxious colds, &c. and even prepares, and purifies the cruder juice the plant is to receive from the earth, by straining it, &c. through its own body. This it continues to do, till the plantula being a little enured to its new element; and its root tolerably fix'd in the ground, and fit to absorb the juice thereof;

*How it shoots
and takes root.*

they erect themselves; M. Parent solves this from the vertical tendency of the nutritious juice up the stem: for the juice being received, in this direction, into the new tender bud, finds at first little resistance; and afterwards, as the branch grows firmer, it furnishes a longer arm of a lever to act by. *Mem. de l'Acad.*

Lastly, M. Astruc accounts for the perpendicular ascent of the stems, and their redressing themselves, when bent; on these two principles. 1^o, That the nutritious juice arises from the root to the top, in longitudinal tubes, parallel to the sides of the plant, which communicate, either by themselves or by means of other horizontal tubes, proceeding from the circumference of the plant, and terminated in the pith. 2^o, That fluids contain'd in tubes, either parallel, or oblique to the horizon; gravitate on the lower part of the tubes, and not at all on the upper.

For hence it easily follows, that in a plant posited either obliquely, or parallel to the horizon, the nutritious juice will act more on the lower part of the canals, than the upper; and by that means insinuate more into the canals communicating therewith, and be collected more copiously therein: thus the parts on the lower side will receive more accretion, and be more nourished than those on the upper; the consequence whereof must be, that the extremity of the plant will be obliged to bend upward.

The same principle brings the seed into its due situation at first: in a bean planted upside down, the plume and radicle are easily perceived, with the naked eye, to

shoot, at first, directly, for about an inch; but thenceforth they begin to bend, the one downward, and the other upward.

The like is seen in a heap of barley, to be made into malt, in a quantity of acorns laid to sprout in a moist place, &c. each grain of barley, in the first case, and each acorn in the second, has a different situation: and yet all the buds tend directly upward, and the roots downward, and the curvity, or bend they make, is greater or less, as their situation approaches more or less to the direct one, wherein no curvature at all would be necessary. Now, two such opposite motions cannot arise, without supposing some considerable difference between the two parts. The only one we know of, is, that the plume is fed by a juice imparted to it by tubes, parallel to its sides; whereas the radicle imbibes its nourishment at all the pores in its surface. As oft, therefore, as the plume is either parallel or inclined to the horizon, the nutritious juice feeding the lower parts more than the upper, will determine its extremes to turn upward; for the reasons already assigned. On the contrary, when the radicle is in the like situation: the nutritious juice penetrating more copiously thro' the upper part than the under; there will be a greater accretion of the former, than the latter; and consequently, the radicle will be bent downwards. And this mutual curvity of the plume and radicle must continue till such time as their sides are nourish'd alike, which cannot be till they are perpendicular. *Mem. de l'Acad. Royale des Scien. An.*

1708.

it then perishes, and the plant may be said to be *delivered*; so that nature observes the same method in plants, contain'd in fruits, as in animals, in the mother's womb.

Its juice an essential oil.

Now, the juice of the seed is an *essential oil*, or *balm*, elaborated and exalted to its last perfection. This juice or oil is not found in the very point, or embryo in the centre of the placenta: all we meet with in that part, is a few fine watery particles, secreted from the placenta: but 'tis in the placentalæ, or cotyledones themselves; which consist of innumerable little *folliculi*, or cells, wherein this oily juice is contain'd, serving to defend the embryo, and preserve it from being corrupted by water, which we all know will hardly pass thro' oil.

Great use of this oil.

Thus if you take, *e. gr.* fennel-seed, cut it thro' the middle, and apply it to the microscope; you will easily perceive a clear shining oil in the cells of each lobe, investing the tender embryo. Without this oil, it were impossible a seed should live a month, and much less a year, or two, entire and uncorrupted in the ground. And accordingly in divers of the mechanical arts, the same means, *viz.* oil, is used, on the same occasions; *viz.* to preserve bodies from putrifying; so that it appears infinitely wise in nature, to have deposited such an oil, or balm in those ampullæ, or cells; that the embryo might remain secure till it came to unfold its parts, prepare for a new, and more perfect way of living, throw aside its placenta, and trust to its roots.

This oil is found in the seeds of all plants: in some, *e. gr.* in almonds, cocoa nuts, &c. in very great quantity; in others, in less; *e. gr.* pepper, arum, &c. where one would scarce imagine any oil at all.

It is call'd the *essential oil* of the plant, because in it chiefly resides the specific taste of each plant. Add, that it is in this, that the virtues of the plant are mostly lodg'd: thus the oil expressed from the fennel-seed, from wall-nuts, &c. is the whole essence of those plants, which taken away, the rest is of little significancy in medicine.

Lastly, in the seed there is another superfluous humour, which *exhales*; and may probably be of the same nature with the spirit or juice of the flower.

Juices of the bark.

Vth Class of juices are those of the *bark*; which is an artful congeries, or bundle of perspirative ducts, and absorbent vessels; admirably explained by *Malpighi* and *Dr. Grew*.

Of these juices there are divers species: for the several humours rais'd and distributed thro' the leaves, flowers, and other parts of the plant, have all circulated thro' the bark: and accordingly are frequently found to distil from wounds made therein. In some cases, even the whole plant is no more than bark; the pulp having been eat out, as in willows, poplars, &c. which will live a long time in that state.

Uses of the bark.

The bark serves divers purposes: for it not only transmits the nutritious juices of the plant, but also contains divers fat oily humours, to defend the fleshy parts from the injuries of the weather. As animals are furnish'd with a *panniculus adiposus* usually replete with fat, which invests and covers all the

the fleshy parts, and screens 'em from external cold ; so are plants encompass'd with a bark, replete with fat juices, by means whereof the cold is kept out ; and, in winter time, the *spicule* of ice prevented from fixing and freezing the juices in their vessels : whence it is, that some sorts of trees remain ever green, the year round, by reason their barks contain more oil than can be spent, and exhaled by the sun, &c.

All the juices of barks are reducible to eight, *viz.*

1^o, The crude, acid, watery juice, which we have already call'd the *chyle* of the plant.

2^o, An *oily juice*, which bursting the bark in the beginning of summer, *oil* exudes out of divers plants, as beech, pine, fir, savin, juniper, and other ever-greens, and such alone. This oil dissolves by the smallest degree of warmth, and is easily inflamed ; and is that which defends the plant, &c.

3^o, A *balm*, * or fatty liquor more glutinous than oil ; being nothing but *Balm* the last mention'd oily juice, which was more fluid, during the spring-time, but which, since, by the greater heat of the sun, has evaporated all its more subtile parts, and is converted into a denser liquor. Thus the finer part of oil of olives being exhaled, by the summer's warmth, there remains a thick balsam behind : Thus also, oil of turpentine having lost its more liquid parts, by heat ; becomes of the thick consistence of a balm.

4^o, A *pitchy juice*, which is the body of the oil it self, inspissated, and *Pitch* turn'd black, further than in the balm. This is most observed in the *pine* and *fir* †.

5^o, A

* There are three principal *balsms* or *balsams* in use among us ; *viz.* balm of *Gilead*, of *Peru*, and *Capivi*. The first, which gives the denomination to all the rest, issues out at incisions made in the body of a tree, call'd *balsamum*, growing in *Egypt* and *Judea*. The juice, call'd also *opo-balsamum*, at first is liquid, but afterwards hardens into the form we see it in. 'Tis rarely had unsophisticated. The marks of purity and goodness are, to have a brisk pungent smell nothing tart, easily dissoluble, astringent and pungent to the taste. Its colour is a golden yellow, and its flavour has somewhat of the citron. The fruit of the tree, call'd *carpo-balsamum*, and the wood *xylo-balsamum*, have somewhat of the virtue of the balm it self.

The balsam of *Peru* is differently denominated, according to the parts it is obtained from : *balm of incision* is a whitish, viscid juice, distilling from incisions in the tree ; and afterwards dried and hardened.

Dry balm, is of a reddish colour, and oozes from the tips of the branches, cut off for that purpose. It is like milk at first, and only reddens by being expos'd to the sun. *Balm by lotion* is black, and comes from the bark, and from little branches and leaves chopt small and boil'd together.

The balsam of *Copau* or *Capivi* comes from *Brasil*. It is in form of an oil ; and is either thick or transparent : the first, white, and of a resinous taste ; the second more on the yellow.

† The pitch in use among us, is said by some to be a gum issuing from the larch, mastic, or turpentine tree ; but in reality is no more than the juice of the pine, or fir, burnt and reduced into rosin, with a mixture of tar, to give it the colour. Sir *G. Wheeler*, gives us the way of preparing pitch, as practis'd in the *Levant* : a ditch being dug in the ground, two yards wide at top, but going less and less towards the bottom ; they fill this pit, with branches of pine ; chusing such as have the most gum, and

Resin.

5°, *Resin*, which is an oil, so far inspissated as to become friable in the cold; and may be procured from any oil, by boiling it much, and long. Thus, if turpentine be set over a gentle fire, it first dissolves, and becomes an *oil*; then a *balsam*; then *pitch*, and then a *rosin*; in which state it is friable in the cold, fusible by fire, and withal inflammable and combustible; dissoluble in spirit of wine, but not in water, which makes the character of rosin*.

Hence the *oil* is most abundant in the barks in the winter time; the *balsam* in summer; and the *resin* in autumn.

Colophony.

6°, *Colophony*, which is a rosin still further exhausted of its volatile part; being pellucid, friable, and approaching to the nature of glass†.

Gum.

7°, *Gum*, which is a humour exuding out of the bark, and by the warmth of the sun concocted, inspissated and rendered tenacious; but still dissoluble in water, and at the same time inflammable, and scarce capable of being pulverized.

Gum, therefore, appears as a sort of saponaceous fat: *i. e.* beside its oily principle, it has some other ingredient, which renders it miscible with water**. With this the gems, or buds of trees, are covered in the winter time.

Gummos resin.

8°, A *gummos resin*, which is a humour secreted in the bark, and dried by the heat of the sun; and thus constituting a body that is partly *gummos*, and as such, tenacious and soluble in water; and partly *resinous*, and therefore friable, and soluble in oil, or spirit of wine, but not in water.

Such are gum *armoniac*, *galbanum*, *bdellium*, *opopanax*, *sagapenum*, *tacamahaca*, &c. part whereof intimately dissolves in water; the rest remaining untouch'd at bottom.

Blood of plants.

VIth Class of juices comprehends the *blood* of plants; or the juice peculiar to each species of vegetables, and not reducible to any common kind of *oils*, *waters*, *balms* or the like||. Thus some plants, upon breaking or bruising their vessels, yield a milky humour, as the *esula*; others a yellow

and observing first to slit 'em into little shivers, which they lay over one another, till the place be full. This done, they cover the pit with fire; which burning the wood, the pitch falls down, and trickles out at a little hole made in the bottom of the pit.

* To this class belong turpentine, mastice, camphor, &c.

Some naturalists distinguish two kinds of resins, *liquid* and *solid*. The first is the juice, just as it distils from the tree: the second only differs from this, in that it has been inspissated by the heat of the sun, or fire.

† The common colophony is only turpentine, boil'd in water, to a solid consistence. Pills made hereof are what we

call turpentine pills, so much used in the venereal disease.

** Such are gum elemy, arabic, anima, tragacanth, benzoin, euphorbium, myrrh, olibanum, storax, &c.

|| These several juices hitherto recounted, are the *first*, or *nutritious juice*, call'd also the *chyle* of the plant, under such alterations and new modifications as it undergoes in being received and kept some time in parts of a peculiar structure, as leaves, flower, seed, &c. This last juice, call'd the *blood*, is the same nutritious juice further altered by being divers times pass'd thro' each of those parts, and remix'd; and at length converted into a new juice with properties different from any of 'em all.

sharp

sharp one, as the *chelidonium majus*; others a yellow bitter one like gall, as aloes; and so of the rest.

The botanists are now well agreed, that all plants are furnished with organs, and parts necessary both for chylication, and sanguification. For they have veins, arteries, heart, lungs, adipose cellules, &c. whence it is obvious, that there must be some difference between the juices which have not undergone the action of those parts, and such as have already circulated a number of times. For, as in an animal, the juices prepared in the *prima via*, i. e. in the stomach and intestines, differ much from the blood; so do the humours of vegetables not yet concocted, differ from such as are already perfectly assimilated.

Helmont, the father, was the first who observed this difference between the juices of plants. That it is real, is evident hence, that tho' this juice be in every part of the plant, the leaves, flower, bark, wood, &c. and trickle out spontaneously, upon any rupture of the canals: yet, if the whole plant be rubb'd or pounded together, no such juice is found therein; but only the common green juices, expressed from all plants.

Thus aloes, *e. gr.* bruised together, yields a mere green juice; tho' the juice distilling from the same, when lightly broke or wounded, be of a golden colour. Thus also the *chelidonium*, if you cut the stem asunder, distils, as already observed, a yellow, golden juice; but if you rub the whole plant together, leaves and all, the juice expressed from it, will be quite of another kind, *viz.* green, which is common to all plants: and thus poppy, when wounded, yields a milky humour, which drying in the sun, becomes black, and is call'd *meconium* or *opium*: but the same poppy, &c. being pounded; the juice expressed, will be found yellow and oily. Add, that the thing which purges so violently in *colocynthis* seems to reside in this juice; for the whole plant has no such effect.

The general chemical character of vegetables, which in the analysis distinguishes 'em from fossils, and animals, is, that when burnt to ashes, they yield a fixed alkaline salt: tho' in some kinds this be very small in quantity; particularly in such as yield a sharp smell, as onions and mustard. *M. Homberg*, 'tis true, assures us he had drawn such a salt from the water of a certain spring; but he himself suspects that salt might have come into the water from the vegetables * growing therein †.

* Vegetable bodies are found more uniform in respect of their elements, than fossils: in the analysis, they all contain salt, water, earth, and sulphur, but then the salt is of three several sorts, *viz.* acid, urinous, and lixivate. *Homberg*, *Mem. de l'Acad. An. 1702*. These principles are all more or less volatile, as a greater or less fire is used: or as the plant has been fermented or not. *Id. ib. An. 1701*.

† Agreeably to the method hitherto observed, it will be necessary to subjoin a scheme, or division of the several subjects of the vegetable kingdom.

Plants, then, are popularly divided, with respect to magnitude, into trees, *arbores*; shrubs, *frutices*; and herbs, or *suffrutices*. Again, with respect to their food, and the element they live in, plants are divided into *terrestrial*, or *land-plants*; *aquatic*
Y or

Chemical character of a vegetable.

or water-plants; and *amphibious*, or those which live indifferently in land or water.

The botanists make more minute distributions: M. Ray particularly, distinguishes plants into 25 classes, or genera: viz. 1°, *Imperfect plants*, which are such as appear to want the flower and seed, as corals, sponges, &c. 2°, Plants producing an *imperfect flower*, and whose seed is too small to be discerned by the naked eye, as fern, polypody, &c. 3°, Those whose flowers want petals, as hops, hemp, nettles, docks. 4°, Those with a *compound flower*, and which emit a milky juice when cut or broke; as lettuce, dandelion, succory, &c. 5°, Those with a *compound flower of a discous form*, and whose seed is wing'd with down; as colts-foot, flea-bane, &c. 6°, *Herba capitata*, or those whose flower is composed of long, fistulous flowers gathered into a round head, and covered with a scaly coat; as the thistle, great burdock, blue-bottle, &c. 7°, *Corymbiferous plants* with a discous flower, but no down; as the daisy, yarrow, corn-marygold, &c. 8°, Plants with a *perfect flower*, but only one seed to each flower, as valerian, agrimony, burnet, &c. 9°, *Umbelliferous plants*, with a flower of five petals, and two seeds to each flower: which being a large genus, is subdivided into 7 species, viz. those with a broad flat seed like a leaf, as wild garden parsnip: with a longish and larger seed, swelling in the middle, as cow-weed, and wild chervil: with a shorter seed, as angelica: with a tuberos root, as the earth nut: with a small striated seed, as caraways, saxifrage, and burnet: with a rough hairy seed, as parslly, wild carrot: with intire leaves undivided into jags, as fenicle, and thorowax. 10°, *Stellate plants*, whose leaves grow round the stalks, at certain intervals, in form of stars; as mugweed, madder, &c. 11°, *Rough-leav'd plants*, which have their leaves placed alternately, or in no certain order along the stalks; as hounds-tongue, mouse-ear, &c. 12°, *Suffrutices or verticillate plants*, whose leaves grow by pairs, on their stalks, one leaf right against another; the flower being monopetalous, and usually in form of a helmet; as thyme,

mint, penny-royal, vervain, &c. 13°, *Polyspermous*, or those with many naked seeds, at least more than four, succeeding their flower, as crow's-foot, marsh-mallows, cinquefoil, strawberries, &c. 14°, *Bacciferous plants*, or such as bear berries; as briony, honeysuckle, Solomon's seal, lilley of the valley, night shade, asparagus, &c. 15°, *Multisiliquous or corniculate plants*, which after each flower produce several long, slender siliqua, or cases wherein their seed is contained; as orpine, navel-wort, bears-foot, columbines, &c. 16°, *Vasculiferous plants*, or those with a monopetalous flower, and which after each flower have a vessel beside the calyx, containing the seed; as henbane, bind-weed, rampions, fox-glove, eye-bright, &c. 17°, Those with an uniform tetrapetalous flower, bearing their seeds in oblong siliquous cases, as stock-jilly-flower, mustard, radish, &c. 18°, *Vasculiferous plants*, with a seeming tetrapetalous flower, but of an anomalous, or uncertain kind, and in reality only monopetalous, falling off all together in one, as speedwell, fluellin, plaitain, yellow and wild poppy, &c. 19°, *Leguminous plants*, or such as bear pulse, with a papilionaceous flower, consisting of four parts, join'd at the edges; as peas, beans, vetches, tares, lentiles, liquorice, trefoil, &c. 20°, *Vasculiferous plants*, with a pentapetalous or five-headed flower; as maiden pinks, campions, chickweed, St. John's wort, flax, primrose, wood-forrel, &c. 21°, Plants with a *true bulbous root*, as garlic, daffodil, hyacinth, saffron, &c. 22°, Those whose roots approach nearly to the bulbous form, as flower de luce, cuckoo-pint, bastard hellebore, &c. 23°, *Culmiferous plants*, with a grassy leaf, and an imperfect flower, having a smooth, hollow, jointed stalk, with a long sharp-pointed leaf at each joint, and the seed contained in a chaffy husk; as wheat, barley, rye, oats, and most kind of grasses. 24°, Plants with a grassy leaf, but not culmiferous, with an imperfect, or stameneous flower; as rushes, cats-tail, &c. 25°, Plants, whose place of growth is uncertain; chiefly water plants, as the water-lilly, milk-wort, mouse-tail, &c.

Of A N I M A L S ;

OR, THE

ANIMAL KINGDOM.

AN animal (respect being only had to the body, not the soul,) is *an Animal defined:* an *organical body, consisting of vessels and juices; and taking in the matter of its nutriment, by a part call'd a mouth; whence it is conveyed into another, call'd the intestines, into which it has roots implanted, whereby it draws in its nourishment, after the manner of plants.*

From this definition it appears, that an animal is distinguish'd, 1^o, From *a fossil*, in that it is *an organical body, consisting of vessels and juices; and* 2^o, From *a vegetable*, on this only account, that an animal has its roots within it self, and a plant without it self. Nor let this appear a paradox: for the intestines of an animal are, in reality, no more than its earth, or the body it adheres to; into which it sends forth its *roots*, that is, the lacteal vessels, which thence draw the matter of its life, and increase.

If it be inquired why we do not define an animal from its *heart*? 'tis answered, that we don't know whether all animals have such a part; for as there are several have 16 hearts, particularly the silk-worm; and some have even 60; so 'tis possible there may be others have none at all. Nor can any general character of an animal be taken from the *brain*, the *lungs*, or the like; since we know of many quite destitute thereof.

The proper genuine characteristic*, then, of an animal, is to be free, and at large with respect to the subject it derives its nourishment from. For every thing is taken in by the mouth; but the mouth does not adhere to any thing. Whereas all plants are connected, in some manner or other, to the body which furnishes 'em food†.

Hence

* The ingenious Dr. Tyson fixes the criterion of an animal to be, a *ductus alimentalis*, i. e. a gula, stomach, and intestines, all which make but one continued canal.

† As circumspect as our author has been in framing his definition, there may, perhaps, be animals it does not agree to; and such we take *mussels* to be. That anomalous creature breathes, and receives its nourishment, not at the mouth, but by the anus. The part which we account its *head*, tho' without either eyes, ears, or tongue, or any other apparatus, save a hole, which we may call its *mouth*; is an immoveable part; being fastened to one of the shells, so, that it cannot go to seek for food, but the food must come to seek it. This food is water,

Hence it follows, that a fœtus, while it remains in the mother's womb is a real plant; as being connected by the *funiculus umbilicalis* to the *placenta*, and by the *placenta* to the *uterus*, from which it receives its nutriment. If it did not derive its food by the said funiculus, but by its mouth, it were an animal*; and if it drew it by both, a *neophyta*, or plant-animal.

Some have defined animals from their loco-motion, as being capable of shifting from place to place; and plants from their sticking fast to the same subject: but on this principle oysters, mussels, cockles, &c. are excluded from the class of animals, inasmuch as they adhere, or grow to rocks, &c.†

yet

water, which, as the shells open, enters in at the *anus* of the mussel, which opens at the same time; and passing thence into certain canals between the inner surface of the shell and the outer surface of the animal, is conveyed thence into its mouth, by a certain motion which the animal can produce at pleasure. From the bottom of the mouth proceeds a sort of intestine, which passing thro' the brain, and making several circumvolutions in the liver, traverses the heart, and terminates in the *anus*. Nor does the canal, taken for an intestine, seem proper to carry the food for the nourishment of the parts; since it does not distribute any branches thereto. Add, that it has no veins, or arteries, nor any circulation: and, what is yet further surprizing, it is an hermaphrodite; but an hermaphrodite differing from all others of that kind known, in that it propagates independently of any other animal, and is it self both the father and the mother of its own offspring. See its anatomy at length in the *Mem. de l'Acad. R. de Scienc.*

* "How the fœtus is nourished in the womb, Dr. Drake observes, is a question as much agitated among anatomists as any whatever: some contend that it is nourished by the mouth; others will have it receive its increase, and grow like a vegetable, from the mother as from the root, of which the umbilical vessels are the stem, and the child the head or fruit." *Anthrop. l. 1. c. 22.* Were it not for that small share of muscular motion, which the fœtus exercises in the womb, it might without absurdity be accounted as a graft upon a branch of the mother. *Id. ib. l. 2. c. 7.*

† Some of our latest naturalists have dis-

covered a progressive motion in several shell-fish, which were reputed to be fixed. M. *Poupart*, in particular, shews that mussels walk on the ground, and some species of 'em, even tumble along the surface of the water. Their way of walking is thus: lying on the flat of their shells, they thrust out a part, in form of a tongue, which from its use may be called the *arm*: with this they make little motions to the right and left, and by that means dig a passage in the sand, or mud of the place. In this digging, they stoop gradually on one side; and so get the shell mounted on edge. This done, they stretch the arm out, as far as they can, for a minute or two; and then rest on its extremity, to draw the shell after 'em, as water-snails do. Which motion they repeat as long as they mean to walk; thus forming themselves a sort of groove, in the sand, which sustains the shell on either side; and leaving behind 'em a sort of irregular track, three or four yards long. In rivers, &c. that abound in mussels, one sees a-bundance of these tracks, and a mussel always at the end of 'em. M. *Poupart* adds, that not having discovered any muscles whereby this motion should be effected, he supposes that they only stretch out of the shell by imbibing a great quantity of water. *Mem. de l'Acad. An. 1706.*

In sea-mussels, M. *Reaumur* has observed, that what we may call the *arm* or *leg*, which in its natural state is not above two lines long, may reach out of the shell above two inches; and the animal having laid hold of some fixed point, with this arm thus stretch'd out, bends, and shortens it, and thus drags the body after.

Mem. de l'Acad. 1710.

Monf.

yet 'tis certain, that those creatures are real animals, as they have mouths and stomachs to take in their food, and lacteals and mesenteric veins to receive it.

We shall add, that beside their proper body, they likewise feed and maintain their house, or *shell*, from the same roots; the shell being found to adhere to the body by an infinity of little vessels, thro' which the circulation is effected.

As to the structure of those shells: they consist of an infinite number of lamellæ, or thin membranes; intermix'd, and fortified with a stoney cretaceous matter, from which arise the vessels abovemention'd. One lamella they produce every year; and put off, or lay aside another, as snakes &c. do their skins*.

Structure of the shells of animals.

Animals

Monf. Mery, in his anatomy of the pond-mussel, shews that the whole belly of the animal, when it walks, thrusts out of the shell, in form of the keel of a ship; and that it creeps on its belly as the serpent does. He even describes the muscles, by whose alternate action the whole mechanism is perform'd. *Mem. de l'Acad. An. 1710.*

The *avignon*, a shell-fish, frequent on the coasts of *Poitou*, of the species of those call'd by the naturalists *chama*, or *hiatula*, adheres, by its shell, to the bottom; and has a motion the length of two horns, which it thrusts out of its shell, and therewith receives, and expels the water it needs for respiration. The *goats-eye* by naturalists call'd *lepas* and *patella*, is a shell-fish, of a single piece, always growing to a stone, upon which its lower surface is applied: the only motion it appears to have, is to raise the shell about a line from the stone; and thus leave so much of its body bare to the water: but M. *Reaumur* shews, that it has likewise somewhat of a progressive motion along its stone.

The *sea-nettle* put *Pliny* in doubt to which class of bodies to refer it, plants or animals; but he concludes, after *Aristotle*, to make it of an intermediate kind. Its most usual figure is that of a truncated cone, the larger base whereof is always fastened on a stone. The planes of its two bases are circular muscles; and there are recti, or streight muscles, proceeding from one to t'other. All the progressive motion of this animal consists in this, that one half of the muscles of both kinds, which are on the side to which it would move, swells and extends; while the other half, thus weigh'd down, is either drawn after

it, or pushes it forward the same way. But the motion here is scarce so swift, or sensible, as that of the hand of a dial-plate. There is another species of sea-nettle, which does not grow to any thing; popularly call'd, and accounted as a *sea-jelly*; which it perfectly resembles, both in colour and consistence: so that if it be held a little in the hand, the single warmth thereof will entirely dissolve it into water. The warmth of a summer's day or two exhales, and reduces it to mere nothing; leaving only behind it a thin pellicle, like a fine parchment. What places it in the class of animals, is, that it has a systole and diastole, the only symptom it gives of life. *Id. ib.*

* The formation of shells is well accounted for by M. *Reaumur*: before him, naturalists had been contented to suppose the animal, and its shell, to arise from the same egg; and to feed and grow together: but that author gives us other notions. He has found by evident experiment, that the shell, *e. gr.* of garden snails, is form'd of the matter that perspires from the body, harden'd after its discharge by the air. 'Tis certain, that all animals do also perspire, and are surrounded with a sort of cloud, or atmosphere, exhaled from 'em, and which 'tis probable assumes somewhat of this external figure: and what snails, &c. have peculiar to 'em, is, that the atmosphere of their perspiration condenses and hardens around 'em, and forms 'em a visible cover, whereof their body is, as it were, the core; whereas what other animals perspire, evaporates, and loses it self in air. This difference arises from the different substance.

TRAN.

Animals consist of firm, or *solid* parts; and *fluid* parts: tho' some reckon a third kind of parts, of an intermediate nature; as *civet*.

*Animal solids
were earth.*

The *solid* parts of an animal are nothing but *mere earth*, whose particles are bound, or connected together by some oil or other humour: and into such *earth* are the bones, membranes, &c. of all animals resolvable.

Thus, having drawn all the moisture we possibly could out of an ox's bone, by boiling it, and from time to time pouring on fresh water, and pouring

transpired; that from snails, &c. being viscid, and cretaceous, as M. *Reaumur* finds by experiment.

On this principle, tho' the shell do the office of an universal bone, it does not grow like a bone, nor like the other parts of an animal, by intro-susception, that is, by a juice circulating within it self; but by *juxta-position*, i. e. an external addition of parts, over one another; as stones are usually suppos'd to grow. And it is worth observing, that there is an animal substance which grows after the manner of fossils.

To be a little more explicit: it must be remembered, that the head of a snail is always next the aperture of the shell, and its tail towards the point or apex thereof; and that its body, from some cause or other, naturally forms it self into a spiral, the different turns or circumvolutions whereof, are in different planes. This suppos'd, take a snail just hatch'd, and yet in its first littleness: since the matter it perspires petrifies around it, it must first have a little cover, proportional to the bigness of its body; and as its body is yet too little to make a turn of one spiral, at least a whole turn; this cover will only be the center, or, as it were, the beginning of a little turn of a spiral. But the animal continues growing: if it ceas'd withal to transpire, 'tis evident that so much as it should be increas'd by, would remain naked: but as it continues to transpire, it makes it self a new covering, in proportion as it grows, which new cover is added at the extremity of the first; and if the snail have grown to make a second spiral turn, the shell also makes a second: at the same time, the animal has likewise grown in thickness, so that this second turn, is bigger than the first. The rest go on in the same manner: and in an ordinary garden-snail there may be some four or five such circumvolutions.

Hence we see why the first turns of a young snail, which, for instance, has only form'd two, are as big as those same turns of an older snail; for what is once form'd of a shell, does not grow any further, except in thickness: and accordingly, tho' the first circumvolutions of a young snail's shell be as long and broad as those of an old one, they are not so thick. *Mem. de l'Acad. R. des Scienc. An. 1709.*

M. *Mery* objects, that tho' this formation may hold in the shells of snails, yet it does not in the shells of mussels: for 1^o, These shells are visibly compos'd of several laminæ, or leaves, which standing out beyond each other, form distinct bands, or zones, on the outer surface thereof; and the little shells are found to have as many of these bands, as the greatest: whence it follows, that mussel-shells grow like the other parts of animals, which, how little soever they be, do always consist of the same number of parts. 2^o, Add, that the bands in the shell of a little mussel, are less than in a large one; and of consequence must grow as the animal does, and in the same manner. 3^o, A mussel has eight little muscles fastened to the inner surface of its two shells: now if the shells did not grow in the same manner as the fish, it would follow, that those which at first were fastened in certain parts of the young mussel, must be continually changing their place of fastening, to the utmost growth of the animal; which scarce seems possible, and has no parallel in any animal known. *Mem. de l'Acad. An. 1710.*

But M. *Reaumur* vindicates his system from all these objections: to the two first he answers, that there are sometimes even more bands in a lesser mussel-shell than a greater; but that this does not argue either intro-susception or juxta-position, being entirely owing to this, that the disten-

tion

pouring off the old, till it come off as clean and pure as it went on; and proceeding, still further, to drain it, by burning it in a very intense fire, till it was perfectly white: its lamellæ appeared all very distinct, and we could easily perceive it to be *mere earth*, which the least force would crumble into dust, for want of the natural cement: yet, the same bone, tender, and friable as it is, if it be but immersed in oil or water, becomes firm and strong again; and more so in oil, than water. This, the metallists, and refiners are very sensible of: for as in the purifying and assaying of metals, it is necessary they have cupels that are incapable of vitrifying; and as all earth, that has oil or salt in it, is convertible by force of fire into glass: they procure some of this pure, animal earth; by burning flesh, bones, or the like, to a white calx: and a vessel made of this, no fire can vitrify; especially if the calx or earth be frequently wash'd in water, to take away all the salt, and sand, which the fire had left.

Now, this *earth* * is the same in all bodies: in effect, the solid part of animals is the same with that of vegetables; setting aside this difference, that the solids of animals may, perhaps, be somewhat more subtile, and volatile, than those of vegetables.

The *fluid parts* of animals, as of vegetables, are still the more crude as they are less distant from the roots, *i. e.* from the lacteal and absorbent vessels. Consequently *chyle* is no other than a vegetable juice; and accordingly, if poured on blood, it swims thereon. This chyle, as it is further prepared in the intestines, and received into the lacteals, approaches more to the nature of an animal juice, and loses of its vegetable nature; till, at length mixing with the blood, and undergoing divers circulations therein, it becomes a perfect animal juice, and is called *blood*.

This blood is the most universal humour in the whole body; as being in reality the source from which are derived, and into which are again discharged, all the other particular juices in the body. The *cruur*, or red part of the blood, again, differs from the *serum*, or watry part; the serum from the *lymphæ*; the lymphæ from the *nervous juice*; this from the humour of the *glands*; that from the *saliva*: the saliva from the *mucus*; the mucus from the *cerumen*, or ear-wax, † &c.

tion of the bands is liable to be disturbed, and two to be made appear as only one, by the edges of the laminæ, that lap over, being broke or wore down, by the attrition of the sand, sea-water, &c. The third difficulty he obviates by a parallel case: crabs, lobsters, &c. are cover'd with an external crust, or shell; and have muscles or ligaments, wherewith they are fastened on the inside thereof: and yet they cast their shells every year; and take new ones: notwithstanding which, they are always found fast tyed in their shells, and never loose therein. Conse-

quently their muscles or ligaments must be transferred from the old crust to the new: and the mechanism whereby that is effected, may be applied to mussels. *Mem. de l'Acad. An. 1716.*

* See the article *earth*, consider'd as an instrument, or element.

† It would carry us too far, to enter into the nature, characters, origin, office, &c. of the several parts, juices, &c. of an animal body: the reader that wants information in these, must be refer'd to the writers of *Anatomy*.

Again,

Again, there are particular humours separated from the several viscera; as the *bile*, from the liver; *milk* from the breasts; the *pancreatic* juice from the pancreas, &c.

The juices of animals are distinguished from those of vegetables by two circumstances.

Distinguished
from the juices
of vegetables.

1^o, In that, when burnt, their ashes are found perfectly insipid; all animal salts being volatile, and flying off with heat: the contrary of which is observed in vegetables; which constantly leave some fixed salts in all their ashes.

2^o, That there is no sincere acid in any animal juice; nor can any acid salt be extracted out of the same: the contrary whereof we find in all vegetables.

Principles of
animals.

Spirit of ani-
mals.

The principles, or component parts of animals, are *

1^o, *Spirit*: by spirit we mean any sulphurous, or oily matter, so attenuated and subtilized, as to become volatile, by the smallest fire, and miscible with water; which characters, where they concur in the same subject, denominate it a *spirit*.

Now, that there is such a spirit in man, and a peculiar one, too, in every man; is evident from dogs; particularly those of the blood-hound kind; which will follow their master's track, and distinguish it precisely, even tho' a thousand other persons have pass'd the same way. Hence, as 'tis by mere force of smelling, that the animal is able to do this; it follows, that there must be some specific matter exhaled from the body of the master, which the animal can distinguish from the *effluvia* of all other persons. Now, this smell cannot arise from the watery part: for pure water is in-odorous, and insipid: But all smells arise from oil or sulphur; consequently, 'tis some subtle, oily, or sulphurous parts, which the dog here distinguishes. And these are what we call *spirit*.

The like spirit is in other animals: Thus, our hunters going out in a morning, will put a hound in the track which a deer, hare, or the like animal has lately been in; and the dog, if he be good, will follow the steps of that particular deer thro' all the cross paths of a thousand others, and at last single that individual deer among a whole herd.

This spirit alone it is whereby animals are distinguished: The other parts afford no criterions. Thus, a dog can scarce distinguish any thing of animal, when kill'd.

Water.

2^o, *Water*, which is always drawn in great abundance from all parts of animals; nay, from the very bones; as well as from the flesh, saliva, pancreatic juice, lymph, blood, serum, and urine: all which, when committed to the fire, are found to consist mostly of water. In the water it

** "Animals afford the same elements, "getables is of three sorts, and that of
"by a chemical analysis, as vegetables; "animals only two, viz. urinous and lixi-
"viz. salt, sulphur, earth, and water; "viate, without any manifest acid." Hom-
"with this difference, that the salt of ve- berg. *Mem. de l'Acad. R. An.* 1702.

is that the spirit resides ; and these two together make the matter of insensible perspiration.

3^o, *Salt* ; but of what kind, we are to learn from the processes here-*Salt* after laid down.

Some learned men will have it an *alkaline* salt ; but this we can safely aver, that we never met with any such salt in any animal body. Nor is it *acid*, (acid chyle being here out of the question, inasmuch as chyle, we have already observ'd, is not any proper animal juice.) Nor is it perfectly *volatile* ; as appears hence, that if you evaporate human blood by a gentle fire, the salt will not rise, but only the spirit, and water. Nor yet is it *fix'd* ; for if you calcine twenty pounds of human blood, you will not get so much as a grain of fixed salt from it. Nor is it a *sal ammoniac* ; for sal ammoniac being sublimed, or raised by fire, remains immutable ; and this, tho' you distil it again, and again : but distillation renders the salt of animals alkaline, and quite destroys all its sal-ammoniacal nature.

Upon the whole, we may call it a compound salt, consisting of a moderately volatile salt ; neither quite volatile, nor quite *fix'd* ; not quite acid, nor quite alkaline, nor quite ammoniacal ; but soft, and benign, and approaching nearest to the nature of a sal-ammoniac. *Of what kind.*

Such is the real idea of the animal salt ; and yet the salts of all animals, if reduced to their last simplicity, are all found perfectly volatile. Human urine, *e. gr.* is a proper lixivium, *i. e.* a salino-saponaceous water, which washes all the salt out of the blood ; and this, if purged of all its other principles, both earthy, watery, and oily, volatilizes with the smallest degree of heat, and flies all away *in fumo*. Add, that it is so acrimonious as to corrode all bodies it touches ; and so light and subtle, as scarce to be retainable in cold, not at all in heat.

Such is the simple elementary salt of animals : but it cannot be shewn, that such salt exists in any urine ; but is the mere result of distillation.

4^o, *Oil*, which being reduced to its last simplicity, resolves into a subtile, or volatile oil, and earth. This oil is various, according to the circumstances of the salts, or other principles inherent in it : But the volatile oil being perfectly clear'd of all salt, and earth, is a simple, inactive body ; and in all respects the same in all animals.

5^o, *Earth*, of which we have already spoke ; and which we have shewn *Earth* to be alike in all animals ; perfectly immutable, and only differing from vegetable earth, in its being a little more volatile.

Animals, consider'd as the subjects of chemical operations, are either taken *whole* ; as in insects : or in *parts* ; which are either *solid*, and *external*, as *shells*, *horns* and *hoofs* ; or *internal*, and *softer* ; as *fat*, *bile*, &c. or *excrementitious*, as *urine*, &c. or, lastly, morbid parts, and excrescencies ; as *pearls*, *bezoar*, *pietra del porco* ; and the like.

OF THE OPERATIONS OF CHEMISTRY.

WE begun the theory of chemistry with a definition of the art itself; noting, by the way, that the whole theory would be comprized under the explication of that single definition. Accordingly, we began to examine the several parts thereof; and shew'd, 1^o, How it was an *art*, from the very idea of art allow'd by all approved authors. 2^o, Its object, *viz. sensible bodies contain'd in vessels*, we divided into general classes, and laid down the several characters and properties of each. This general division of nature comprehends three kingdoms; each of which we subdivided into inferior classes, or provinces: and have thus given a philosophical account of all bodies that are known, and have any relation to chemistry——It remains, that we proceed in the further explication of the same definition. And, as we have said, that chemistry *changes the bodies*, already mention'd, by *means of certain operations*; we are to treat of these operations.

Chemical operations change bodies by means of motion.

Now every operation which chemistry performs on bodies, *changes* those bodies; for unless they were changed, chemistry would have done nothing: and every *change* which chemistry produces in bodies, is the effect of *motion*: For who can conceive a thing changed, without a motion made either in the parts, or the whole? If a body be absolutely at rest, it will still excite the same idea, *i. e.* it will not be at all changed: But when a motion is communicated to it, it is frait changed, and changes the idea the mind had before conceived of the same *.

Ts

* Motion, thus, being the means whereby chemistry operates; the doctrine of motion, *i. e. mechanics*, becomes the key, whereby its operations are to be accounted for. So far, then, as we know of the nature, and laws of motion; so much we may conceive of the means whereby a chemical effect is produced. But our knowledge

'Tis a mistake, therefore, in certain chemists, who deny the changes produced by chemistry to be *mechanical*; among whom, is *Helmont* the elder, who contends for I know not what irradiation, excited by the art. But we ask, whether mercury, without it be some way moved, will not still remain mercury? And whether, if the philosopher's stone convert it into gold, the change is not effected by motion? We own, there is no ac-

knowledge here, God knows, is very scanty, and confined to narrow bounds: many of the laws of motion, percussion, &c. in sensible bodies, under various circumstances, as falling, projected, &c. are well ascertained by the later philosophers; but these will not reach to those more remote, intestine motions of the component particles of those same bodies, whereon the changes of texture, colour, properties, &c. induced by chemistry, depend. Beside the common laws of sensible masses, the minute parts they are composed of, seem subject to some others, which have been but lately taken notice of, and are yet little more than guess'd about. Sir *I. Newton*, to whose happy penetration we owe the hint, contents himself to establish, that there are such motions in the *minima natura*, and that they flow from certain powers, or forces not reducible to any of those in the great world. In virtue of these powers, he shews, that the small particles of bodies act on one another even at a distance; and that many of the phenomena of nature are the result hereof. Even sensible bodies, we know, act on one another divers ways; as by gravity, magnetism, and electricity, which are directed by different laws: And as we thus perceive the tenor and course of nature, it will appear highly probable, there may be other powers. These just mention'd, reach to sensible distances, and so have been observ'd by vulgar eyes: But there may be others, which reach to such small distances, as have hitherto escaped observation; and 'tis probable electricity may reach to such distances, even without being excited by friction.

The great author just mention'd, proceeds to confirm the reality of these suspicions from a great number of phenomena, and experiments which plainly argue such powers and actions between the particles, *e. gr.* of salts and water, oil of

vitriol and water, *Aqua fortis* and iron, spirit of vitriol and salt-petre. He also shews, that these powers, &c. are unequally strong between different bodies, between the particles of salt of tartar, for instance, and those of *Aqua fortis*, than those of silver; between *Aqua fortis* and *Lapis calaminaris*, than iron; iron more than copper, copper more than silver or mercury. So, spirit of vitriol acts on water, but more on iron or copper, &c.

These actions, in virtue whereof the particles of the bodies above-mention'd tend toward each other, the author calls by a general, indefinite name, *attraction*; which is equally applicable to all actions whereby bodies tend towards one another, whether in virtue of their weight, magnetism, electricity, impulse, or any other more latent power: for 'tis not the cause determining the bodies to approach, that he expresses by this name; but the effect, *i. e.* the approach: the cause he has no regard to, till such time as the effect is well ascertain'd. In his philosophy, the research into causes is the last thing; and never comes in turn, till the laws and phenomena of the effect be settled: it being to these phenomena that the cause is to be accommodated. But the cause even of any, the grossest, and most sensible of these actions, is not adequately known: How impulse itself works its effect, would confound the deepest philosopher; yet is impulse received into mathematics: and the laws and phenomena of its effect, make the greatest part of the *common mechanics*. The other species of attractions, therefore, when their phenomena are sufficiently ascertain'd, have the same title to be promoted from physical to mathematical consideration; and this without any previous inquiry into their causes, which our conceptions may not be proportionate to: Let their causes be *occult*, as all causes ever will be; so as their effects, which alone

accounting by what motion the stone should in a moment's time change all the particles of the mercury into gold: but it will be evident to any person who attentively considers the thing, that there must be some infinitely little corpuscles; which penetrating the minute globules of the mercury, fix and bind them together. And the same may be said of the action of an universal dissolvent, which is to reduce gold into its principles, viz. mercury and sulphur: For must not there be a real separation of the particles?

To this it is objected by some modern philosophers, that there is motion frequently produced from principles which are at rest: Thus, say they, the magnet is not moved, and yet it attracts iron; so the soul, unmoved itself, moves the body at pleasure.

To which we answer, that we never maintained the first cause of motion, to be a motion; but only, that if one body change, or act on another, 'tis wholly by means of motion that it is enabled to effect it: Thus the magnet, to change the iron, or to act upon it, must move it. And thus the mind, to act on the body, must give it motion*.

All

immediately concern us, be but apparent. Our noble countryman, then, far from adulterating philosophy with any thing foreign or metaphysical, as some have reproach'd him; has the glory of opening a new source of sublimer mechanics, which, duly cultivated, might be of infinitely more extent than all the mechanics yet known. 'Tis hence alone we must expect to learn the manner of the *changes, productions, generations, corruptions, &c.* of natural things; which are the great object of that part of philosophy call'd *chemistry*.

Some of our own countrymen have prosecuted the discovery with laudable zeal: Dr. Keill, particularly, has endeavour'd to deduce some of the laws of this new action; and applied them to solve some of the more general phenomena of bodies, as *cohesion, fluidity, elasticity, softness, fermentation, conglutination, &c.* And Dr. Friend, seconding him, has made a further application of the same principles, to account, at once, for almost all the phenomena that chemistry presents. So that the new mechanics should seem already rais'd to a compleat science: And nothing can now turn up, but we have an immediate solution of, from the attractive force.

But this seems a little too precipitate; a principle, so fertile, should have been further exhausted; its particular laws, limits, &c. more industriously detected,

and laid down, e'er we had gone to application. Attraction, in the gross, is so complex a thing, that it may solve a thousand different things alike: The notion is but one degree more simple, and precise, than action itself: and till more of its properties are ascertain'd, it were better to apply it less, and study it more.

*The same holds in the natural world; all the phenomena, the changes in the universe, are the effects of motion. Accordingly, to have a succession of such changes, the author of nature has added to bodies, certain active principles to be the sources of motion.—Nature, says Sir I. Newton, performs all the great motions of the heavenly bodies by the attraction of gravity, which intercedes those bodies; and almost all the small ones of their particles, by some other attractive, and repelling powers which intercede the particles. Body itself, is merely passive, and needed some other principle to move it; and now that it is in motion, it needs some other principle for conserving that motion. By the tenacity of fluids, the attrition of their parts, and the weakness of elasticity in solids, the motion which we find in the world, is always dwindling, and on the decay; so that there arises a necessity of recruiting it by active principles: such are the cause of gravity, by which planets and comets keep their motions in their orbs, and bodies

All the operations, therefore, which chemistry performs on bodies, are mere changes in respect of motion. Now a body may be changed, in motion, two ways: either when its whole bulk is removed from place to place; which does not come under the consideration of chemistry, but of mechanics: or, when its parts are changed among themselves, *i. e.* when there is a transposition of its constituent parts.

Of this last kind of change, there are four cases. 1^o, When motions, which before did not exist, are excited. 2^o, When motions before existing, are stopped. 3^o, When motions are increased or diminished. 4^o, When they are determined, or new modified, without any change of the quantity of motion. To some or other of which heads, may all the possible changes in the parts of bodies be referred.

Hence we conclude, that the mutation induced by chemistry, does not go so far as the last elements or atoms †: for all action terminates in the separation of the elements, without making any alteration therein. If any person thinks to go further, he is wretchedly mistaken: For my own part, I know of no operation, but has its limit; beyond which, it does not proceed. Thus, pure gold may be converted by spirit of sea-salt into a sort of water; but if any body should think that the gold is now changed, he will be undeceived, by seeing the whole gold reduced into its former pure mass, without the loss of one millionth part of a grain. Pure gold may likewise be converted into a butter: but it is easily return'd into its former state. I can dissolve one single grain of gold in a thousand grains of mercury, and recover it without any diminution of weight.

bodies acquire motion in falling; and such the cause of fermentation, by which the heart and blood of animals are kept in perpetual motion, the inward parts of the earth are constantly warm'd, bodies burn and shine, mountains take fire, caverns blown up, &c. For we see but little motion in the world, beside what is owing to these active principles: And were it not for these, the bodies of the earth, planets, comets, sun, and all things in them, would grow cold, and freeze, and become unactive masses. *Optic.* p. 373, & 375.

† Thus the great *Engl^{sh}* philosopher: All bodies seem to be composed of hard particles; for all bodies, so far as experience reaches, are either hard of themselves, or may be render'd hard; *viz.* some by freezing, as waters, oils, &c. others, as mercury, by fumes of lead; and spirits of wine, and urine, by dephlegmating and mixing them: even the rays of light themselves are hard bodies, as appears from their retaining different properties in

their different sides. Many compound bodies are very hard, notwithstanding that they are very porous, and consist of parts that are only laid together: How much harder, then, must the simple particles, or atoms themselves be, which are entirely devoid of all pores? And how such particles, by only laying them together, and touching in a few points, should cohere, and so firmly, without the intervention of something that attracts, or perhaps even presses them together; can scarce be conceiv'd. These simple or smallest particles cohering by the strongest force or attraction, compose bigger particles of feebler virtue; and many of these cohering, compose other particles still bigger, and more weakly united: and so on for divers successions, till the progression end in the biggest particles, on which the colours of natural bodies, and the operations in chemistry depend; which, by cohering, compose masses, or bodies of a sensible magnitude. *Nesutan. Optic.* p. 364, & 370.

From.

From all which it appears, that the elements of gold are immutable ; so that art goes no farther than to compounds.

Nor can the wisdom of the supreme Being be ever enough adored, in creating the elements so firm and unchangeable ; otherwise, the whole visible world had by this time been changed into quite another form ||. *Helmont* himself asserting a radical solution of parts, seems to confirm this doctrine : for, says he, "*Desperata ulterior mutatio, quia non invenit cui misceret.*"

Chemical changes reducible to two kinds.

Now, the changes of motion which chemistry produces in bodies, are reducible to two kinds ; viz. an *union* of parts, and a *separation* of the same. Thus, chemistry separates spirits, salts, oils, &c. from bodies ; and again unites, or compounds them together.

Nature of a chemical operation.

A chemical operation, then, consists in changing the situation of the parts ; particularly, either in moving some parts, but not the whole ; which is call'd *separating* ; or in adding new parts, which is call'd *uniting*.

Operations reducible to two kinds.

All *chemical operations*, therefore, are reducible to two kinds ; viz. such whereby the parts of bodies, before joined and united, are separated from each other ; which is call'd by the antient chemists, *solution* : And such whereby the parts before disjoined, are combined, or united ; which is call'd *coagulation*.

Solution.

Coagulation.

And hence, chemistry may be defined, *the art of changing bodies by solution, and coagulation*. In effect, chemistry in all its latitude is either the *separating of parts before united, or uniting parts before separated*, i.e. either the *adding of bulk to bulk, or separating of bulk from bulk*.

Some, however, object *digestion*, as a third species of operation, not reducible either to *union* or *separation* ; the mass, in this case, being supposed to remain the same as before : Thus, say they, if you take aloes, myrrh, and saffron, and pouring spirit of wine upon them, digest them for the space of a month, to make an elixir ; there is neither union nor separation made ; but the mass is the same, without either addition or diminution. To which we answer, that there is both a separation, and a new union or composition ; for the sulphurous part of the spirit of wine is evidently united with the parts of the aloes, myrrh, and saffron : And in

|| To this purpose, the philosopher last mention'd, closes a fine inquiry into the nature, laws, and constitution of matter—
" All these things consider'd, it seems
" probable to me, that God, in the beginning, created matter in solid, massy, hard, impenetrable, moveable particles—incomparably harder than any
" of the porous bodies compounded of them : nay, so hard as never to wear,
" or break in pieces ; no human power being able to divide what God made one, at the creation. While these particles continue entire, they may compose bodies of one and the same na-

ture and texture in all ages : but
" should they wear away, or break in
" pieces ; the nature of things depending
" on them, would be changed ; water,
" and earth, composed of old worn particles, and fragments of particles, would
" not be of the same nature now, as water and earth composed of intire particles at the beginning. And therefore,
" that nature may be lasting, the changes
" of corporeal things are to be placed only in the various separations, and new
" associations and motions of these permanent particles." *Newton. Optic. p.*
375, 376.

order

order to this union, there must first be a separation; *i. e.* the juice of the aloes is separated from the vessels it was before contain'd in; and out of the *stamina* of the saffron is drawn an oily matter, to be mixed with the spirit of wine; leaving an insipid inodorous earth behind.

Some still think the division too simple; and subdivide it into a number of particular operations; as *calcination*, *vitrification*, *sublimation*, *fermentation*, *putrefaction*, &c. all of which do really come under the two general heads abovementioned.

Thus, *calcination* is only a separation of all the fluid parts from the solids; after which, all that remains, is earth: or, calcination is the union of the salts, and earth. So also *sublimation* is a separation of the volatile parts from the fixed, &c.

But, as to the effect of the *chemical separation*, there is some dispute among the chemists: the generality will have it a division of the bodies into such lesser bodies or corpuscles, as they before consisted of: so, as the separation does not make any body exist, which had not an existence before.

But others, and with good reason, hold, that all our operations, in separating the parts, do really render them different from what they were, when united; and that the corpuscles, or *principles* we resolve them into, did not exist such before the operation. Thus, say they, distil wine over and over, and you will successively get spirit of wine, vapid water, subacid water, a more acid water, oil, bitter yellow spirit, and a *caput mortuum*, which is resolvable into earth, oil, &c. Now, do not say you have resolved the wine into its component parts: for if you remix these elements, you will thereby have a detestable mass, vastly different from the primitive wine.

Again, distil wine, or the juice of the grape, with all your art, and you will never get out any spirit of wine; but add some ferment, or barm, and the alcohol will readily rise. Again, when plants are burnt, there always remains a fixed salt in the earth, or vessels; how vehement soever the fire have been: but if those plants have putrified a little, the salts are all volatile. Whence it appears past doubt, that some of our operations make a great change in the bodies*.

Again,

* Mr. Boyle, in his *Sceptical Chemist*, furnishes abundance of curious things on the chemical principles, or *elements*. Fire, he clearly proves, does not barely take the elementary ingredients of bodies asunder, but also alters them; and substances are thereby separable from bodies, which were not pre-existent therein: we don't mean materially pre-existent; but only in that form: nor even that some things may not be procured from mix'd bodies that were more than barely materially pre-ex-

istent; but only, that several things obtain'd from a mixed body, exposed to the fire, were not its ingredients before; and that the substances called principles, may be produced, *de novo*, various ways. In order to this, he observes, that the operation of fire does sometimes not only divide mixed bodies into minute parts, but also compounds those parts after a new manner; whence there may result as well saline, and sulphurous substances, as those of other textures. Thus soap, which

Bodies not reduced to their first elements.

Again, the chemists usually teach, that by their operations, bodies are resolved to their first component principles, or elements: but this is a delusion: We do not, cannot make any such separation. For by *element**, is understood such a minute, simple, homogeneous corpuscle, as is not capable

as known to be an artificial composition of oil or grease, salt and water incorporated together, being exposed to a gradual fire in a retort, will separate, but not into the same substances whereof it was compounded; but others, of a very different kind. Add, that from many vegetables, there may, without any addition, be procured glass, a body surely not pre-existent in them, but produced by the fire: And from mercury, by a proper management, a fourth part of clear water may be procured; tho' tis no way possible any such quantity of water should be contain'd in a fluid fourteen times heavier than water: How, then, can we be sure that phlegm is barely separated, not produced in other bodies by the action of fire; for we know of but few, if any bodies, of a more unalterable nature than mercury. To say no more, a vegetable may be nourish'd, and grow up of water alone; and such vegetable, by a common analysis, yield all the principles: Now, if out of fair water alone, nor only spirit, but salt, oil, and earth may be produced; it follows, that salt and sulphur, &c. are not primogeneal bodies and principles; since they are daily made out of plain water, by the texture which the seed, or seminal principle of plants, gives it. Nor would this seem so strange, did not we overlook the obvious, and familiar operations of nature: for if we consider, what slight qualities they are, that serve to denominate a chemical element; we shall find, that nature frequently produces as great alterations in several portions of matter. To be readily dissoluble in water, is enough to make a body pass for a salt: yet we see not why, by a new arrangement, and disposition of component particles, it should be harder for nature to compose a body dissoluble in water of a portion of matter that was not so before, than of the liquid substance of an egg, which will easily mix with water, to produce, by the bare warmth of a brooding hen, membranes, tendons, fea-

thers, &c. not dissoluble in water. See the article *Fire*.

* Agreeably to this definition, *elements* or *principles* are defined by M. Homberg to be the most simple matters into which a mixed body is reducible by chemical analyses: but the chemists do few of them use the word with so much reserve; chusing rather to conceive, and speak of *elements* as the very primary corpuscles whereof mixed bodies are composed: A way of conceiving, which subjects them to infinite difficulties, and is the foundation of a good part of the objections made against them by Mr. Boyle.

The ancient chemists allow but of three elements; viz. salt, sulphur, and mercury; which they more emphatically call *hypostatical principles*, or the *tria prima*. To which the moderns have added two more, viz. water and earth.

These principles took their denomination from certain qualities observed in the several substances procured in analyzing of bodies by fire: an inflammable substance rising, that would not mix with water, they call *sulphur*: what comes over sapid, and dissoluble in water, passes for *salt*: what is fix'd, and indissoluble in water, they name *earth*: and all the volatile substances, *mercuries*. Or thus,

A body, in distillation, usually separates into volatile, and fixed parts; and those volatile parts either ascend in a dry form, which, if it be sapid, they call *volatile salt*; or in a liquid form; which liquor is either inflammable, and so passes for *sulphur*, or *oil*; or not inflammable, and yet subtil, and pungent, call'd *mercury*, or *spirit*; or else insipid, term'd *phlegm*, or *water*: for the fixed part, it usually consists of particles, partly soluble in water, and sapid; which therefore make *fixed salt*; and partly insoluble, and insipid, call'd *earth*.

The distinct offices of each in the composition of bodies, they thus assign: Salt is the basis of solidity and permanency; that this may be dissolved into minute parts,

pable of being further divided, diminished, or changed by any operation yet known. Thus, if we did not know any way of changing spirit of wine, so as to make it any other thing; or of changing the particles of mer-

parts, and convey'd to the other elements, there is a necessity of water: and that the mixture may not be too rigid, and brittle, a sulphurous or oily principle must intervene, to make the mass more tenacious: To this a mercurial spirit must be superadded, which, by its activity, may permeate, and, as it were, leaven the whole mass, and thereby promote the more exquisite incorporation of the ingredients. To all these a portion of earth must be join'd, which, by its dryness, and porosity, may soak up part of the water wherein the salt was dissolved, and concur with the other ingredients, to give the body the requisite consistence.

These principles are usually divided into *active* and *passive*; the active are the *tria prima*, or three hypostatical principles; the passive are earth and water, which are also call'd *elementary* principles. But M. Homberg has reform'd this division: sulphur he makes the only *active* principle; earth the only *passive* one; and all the rest *intermediate* principles. Sulphur is the active principle, in regard, according to him, 'tis this alone that acts of itself, and that makes all the rest act. Earth is denominated a passive principle, as it never acts, but serves merely as a matrix or receptacle of the other principles: And salt, water, and mercury, are call'd *intermediate* principles, because they do not act of themselves, and yet become capable of acting, by their being join'd with sulphur, which modifies them, and is modified by them a thousand ways. *Mem. de l'Acad. An. 1702.*

Mr. Boyle attacks the common doctrine of the chemical elements, with admirable force and address; making appear, that the different substances into which mix'd bodies are commonly resolved by fire, are not of a pure and elementary nature; but retain so much of the concrete that afforded them, as to appear still compounded; and often to differ in one concrete from principles of the same denomination in another: that, as to their number, it is

not precisely three, as the chemists have usually maintain'd; because in most vegetable, and animal bodies, earth and phlegm are also found; but that there is no one determinate number into which the fire universally resolves all compounds, mineral and others: And that there are several qualities which cannot be refer'd to any of these substances, as if they primarily resided therein; there being, withal, other qualities, which, tho' they seem to have their chief, and most ordinary residence in one or other of these principles, are not yet so deducible from it, but that more general principles may be taken in. *S. sept. Chym.*

It may be alledged, that bodies are only call'd salt, sulphur, mercury, &c. on this footing, that the principle of the same is predominant therein; but it does not even appear, that the reputed salt, sulphur, or mercury, principally consists of one simple body to give it that denomination; or that there is any such primitive, simple substances existing in the bodies whence these are procured. If it be demanded, then, what it is that the chemical analyses of bodies do prove? We answer, that mixed bodies included in close vessels, are resolvable into several substances different in some qualities, but chiefly in consistence: so that out of most bodies may be obtain'd a fixed substance, partly saline, and partly insipid; an unctuous liquor; and another fluid, or more, which, without being unctuous, have a manifest taste. Now, if the chemists will agree to call the dry and sapid substance, *salt*; the unctuous liquor, *sulphur*; and the other *mercury*; we have nothing to object: But if they will obtrude this salt, sulphur, and mercury on us, as simple, and primary substances, whereof each mixt, is actually compounded, and which were really therein antecedent to the operation of the fire; they go further than their experiments will bear them out. And as an element ought to be perfectly similar, and homogeneous; there is no just cause why we should give a body

mercury, but they should still be mercury: we might call these, *elements*. But do the chemists bring all bodies to such elements? No: for there is

no

proposed the name of any particular element or principle, because it bears a resemblance thereto in some obvious quality, rather than deny it that name, on account of several other qualities, wherein it is unlike. *Boyle, ubi supra.*

The chemists will not allow the salt in ashes to be call'd *earth*; notwithstanding that the saline and earthy parts correspond in many respects; e.g. weight, dryness, fixedness, and fusibility; for this only reason, that the one is sapid, and dissoluble in water, and the other not: beside, that sapidness and volatility denominate the chemists *spirit*, or *mercury*. And yet, how many bodies may happen to agree in those qualities, which have different natures, and divers disagreeing qualities?

For not only spirit of nitre, *Aqua fortis*, spirit of salt, oil of vitriol, spirit of alum, spirit of vinegar, and all saline liquors distill'd from animals; but all acetous spirits of woods, must belong to their mercury: tho' it does not appear why some of these should rather come under that denomination, than the chemists sulphur, or oil; for their distill'd oils are fluid, volatile, and sapid, as well as their mercuries. Nor is it necessary that sulphur should be unctuous, or indissoluble in water; since spirit of wine is generally refer'd to sulphurs, tho' it be not unctuous, and will readily mix with water. So that nothing but bare inflammability is left to constitute the essence of the chemists *sulphur*; as the contrary, join'd with any taste, entitles a distill'd liquor to their *mercury*. Now, since spirit of nitre, and spirit of hart's-horn will boil together, hiss, and throw up one another into the air, which the chemists allow for indications of great contrarieties in bodies; since I have obtain'd two sorts of oil from the same parcel of human blood, which would not mix with one another; and since we meet with numerous instances of other contrarieties in bodies, which, according to the chemists, must be huddled up together, under one denomination: It may be worth considering how far such a mul-

titude of substances, as may agree in these slight qualities, and yet disagree in others, deserve to be call'd by the same name of a principle, rather than have such appellations as distinguish them from bodies they differ so much from.—When, unable to shew that a liquor is, for example, purely saline; they prove, that at least salt is the predominant principle therein, from this consideration, that it is strongly tasted; and that all taste proceeds from salt: whereas spirits, as of tartar, hart's horn, &c. which are reputed the mercuries of the bodies that afford them, have manifestly a strong and piercing taste. And indeed, if taste belong not to the spirit, or mercurial principle of vegetables, and animals; we scarce know it will be distinguished from their phlegm; since, by the absence of inflammability, it must be distinguished from sulphur. Add, that not only the spirits of vegetables, but their oils, are very strongly tasted; and the most elaborate depuration will scarce ever reach to make them tasteless. —

Again, volatile salt of hart's-horn, &c. is very strongly scented, notwithstanding that most chemists deduce odours from sulphur, and from them argue the predominancy of that principle in the odorous body.—From the whole, it appears how dissimilar each of those bodies are which the chemists call the salts, sulphurs, or mercuries of the bodies which yield them; as if they had all a simplicity or identity of nature: whereas salts, for instance, if they were all elementary, would differ as little as the drops of pure and simple water: So that we have no positive knowledge of the chemical principle sulphur, by means of analyses, or the de-compounding of mixts. This led M. Homberg to imagine, that something might be learn'd of it from compositions, or artificial mixts: The effect of a great number of operations of which kind, gave him indications, that 'tis light or fire is the real principle sulphur, and the only active matter in all mixts. So that we must refer the disquisition into the nature, properties, &c. of sulphur, to the article of Fire.

In

no operation yet discover'd, which leaves a body out of a capacity of being further changed †.

Che-

Indeed it should be express'd, what kind of division by fire is to determine the number of elements; for the same body, *e. gr. guaiacum*, which, burnt in an open fire, only resolves into two, *viz.* ashes and soot; if distill'd in a retort, dissolves into oil, spirit, vinegar, and water and charcoal; the last of which, by a further degree of fire, in a close vessel, falls into ashes, *i. e.* into salt and earth; and by a farther yet, into glass. If, then, oil passes for an element, because producible by one degree of fire; why is not glass? There are some mix'd bodies, from which it does not appear that any degree of fire will separate any of the common elements; such is gold, and perhaps also silver, *Venetian talc*, *osteo-colla*, and glass; which, tho' made of a pure colligation of the salt and earth remaining in the ashes of a burnt plant; yet will so far resist the violence of fire, that it has been held more irreducible than gold: But if an artificer can unite such comparatively gross particles, as those of earth and salt, into a body indissoluble by fire; why may not nature associate in several bodies the more minute elementary corpuscles, too firmly to let them be parted by fire? There are some bodies whose component principles are so minute, and so firmly united, that their corpuscles need less heat to carry them up, and dissipate them, than is requisite to divide them into their principles. And hence it is, that the common sulphur becomes so difficult to decompose. *Boyle Sept. Chym.*

We have no evidence, that three is precisely and universally the number of the distinct substances or elements, into which all mix'd bodies are resolvable by fire: If it be granted, that the elements at first consisted of certain small primary coalitions of the minute atoms, or particles of matter, into corpuscles very numerous, and like each other; it will rather appear, that such primary masses may be of far more sorts than three, or five: and, consequently, we need not suppose that in every compound body there should be found just three sorts of such primitive

coalitions. It is impossible but that two sorts of elementary bodies may suffice; as we see is the case in that durable substance, glass; while others consist of three, another of four, another of five, &c. Nay, it does not seem impossible, but there may be two, or more sorts of mixts, which have none of the same elements as the other: as we often see two words, whereof the one has not any of the letters in the other; or, as happens in electuaries, wherein no ingredient, except sugar, is common to any two of them. And this is confirm'd by chemical experiments: For as from some bodies, *e. gr.* gold, even three principles cannot be procured; so from others, *e. gr.* grapes, variously managed, may be procured at least a dozen.

† Fire, even when it does divide a body into substances of various consistences, does not commonly analyse it into hypothetical principles; but only disposes its parts into new textures, and thereby produces concretes of a new, indeed, but of a compound nature: And there are many distinct substances obtainable from some concretes without fire, which no less deserve the denomination of elementary, than those extorted by fire. In reality, different degrees of fixity, and volatility, seem to have a great effect in the producing of different elements. For, that fire frequently divides bodies on this only account, that some of their particles are more fixed than others, tho' either of the two be all the while far from pure and elementary, is obvious in the burning of wood, which the fire separates into smoke and ashes; the former of which, confessedly consists of two such different bodies as earth and salt; and the latter, condensed into soot, discovers itself to contain salt, oil, spirit, earth, and phlegm; all which being almost equally volatile in that degree of fire which forces them up, are carried away together. Beside, if two different bodies, united into one mass, be both sufficiently fixed; the fire finding no parts volatile enough to be carried up, makes no separation at all.

Boyle ubi supra.

Chemical elements.

Compound bodies; instances in

Pblegm.

Chemistry, then, does not resolve bodies into *pure, simple, immutable elements*; for *phlegm, spirit, salts, and oils*, into which bodies are used to be resolved thereby, may be changed and further resolved: thus,

1^o, *Pblegm*, drawn by distillation from vegetables, does always carry with it somewhat of the smell of the vegetable, which it derives partly from the *oil*, and partly from the *spirit* residing therein. The same *phlegm*, by frequent distillation, lays aside most of this smell, and approaches nearer to pure water; but never becomes perfectly such. Add, that the purest distill'd water, if exposed a few days to the sun, is much changed, and render'd turbid*.

2^o, *Spirits*,

It does not appear that all mixtures are of elementary bodies; but rather, that there are several compounds even in regard of their ingredients consider'd antecedently to their mixture: for tho' some may be made up of the immediate coalitions of the elements, or principles themselves; yet others, are mix'd at second hand: now if a compound consists of ingredients not merely elementary; 'tis easy to conceive, that the substances into which fire resolves it, tho' seemingly homogeneous, may be of a compound nature; those parts of each body that are most akin, associating themselves into a compound of a new kind. Thus, out of distill'd liquors, which are reputed the elements of the bodies whence they are drawn, *viz.* oil of vitriol, and oil of turpentine; the same author, without any addition, procured a third, *viz.* a true, yellow, inflammable sulphur, the two liquors afterwards remaining distinct: and from the spirit of boxwood, highly rectified, he procured an acid liquor, that would dissolve coral; leaving a spirit of a very different nature from the common spirit of that wood: so that at least, some of the elements, are far from an elementary simplicity, and may be still look'd upon as mix'd bodies. Add, that as there may be more elements than 3 or 6; so the elements of one body may be different from those of another: whence it follows, that from the resolution of compound bodies, there may result mixtures, wholly of a new kind, by the coalition of elements, perhaps never convened before. *Id.*

Helmont gives us a way of converting oils of cinnamon, blood, harts-horn, or the like, wholly into volatile salts, by a bare mixture of their own alkaline salts: if, then, such saline volatile substances, which pass

for elementary, be producible of chemical oils, and fix'd salts, the one made volatile by the other, and both associated by the fire: it may well be suspected, that other substances, arising from the separation of bodies, by fire, may be new sorts of mixtures, and consist of ingredients of different natures. Thus, particularly, I have sometimes suspected, that since the volatile salts of blood, harts-horn, &c. are fugitive, and of an exceeding strong smell; 'tis either an error to ascribe all odors to sulphurs; or that such salts consist of some oily parts, well incorporated with the saline ones: and the like conjecture I have also made, as to spirit of vinegar, which has a piercing smell. *Id. ibid.*

* That *phlegm* is not an elementary body, appears from its different powers and properties: the phlegm of wine, and most liquors, have qualities, that make 'em differ both from mere water, and from one another: the phlegm of vitriol, Mr. Boyle observes, is an effectual remedy against burns; and a valuable nostrum for discussing hard tumours: that of vinegar will extract a saccharine sweetness out of lead, and even dissolve corals with long digestion: that of sugar of lead, is said to dissolve pearls. *Scept. Chym.*

The characters which serve to denominate a fluid *phlegm*, or *water* among the chemists, are insipidity, and volatility; yet quicksilver has both these, which no body pretends to be phlegm. Add, that it appears from several experiments, that water it self, by repeated distillations, may be converted into earth. *Boyle's Production of Chym. Princip.*

Water has a much fairer pretence to be an element, than any of the *tria prima*: the chief qualities that occasion men to give that

2^o, *Spirits*, how simple, and immutable soever they may appear, are yet capable of being decomposed: for, the most simple, highly rectified spirit of wine, call'd *alcohol*, which uses to burn quite out, without leaving any faces at all, is yet found to consist of an acid, and a greatly attenuated oil; and if it be digested with salt of tartar, does half of it turn into water: the remaining spirit, at the same time, becoming so weakened by the salt, as to lay aside its hot, fiery taste. Indeed it must not be omitted, that as there is air in all vessels, wherein spirits are raised, and caught; and as along with air, there is always intermix'd water, and divers other bodies; 'tis no wonder that the spirit should not be found perfectly simple, nor that it is impossible perfectly to purge the spirit of all its water or phlegm †.

3^o, *Salts*,

that name to any visible substance, are, that it is fluid, insipid and inodorous: but we have never seen any of those separated substances, chemists call phlegm, perfectly destitute both of taste and smell. Common salt, and several other saline bodies distilled ever so dry, will each yield a large quantity of phlegm; which can be no other way accounted for, but from this, that among the various operations of the fire, on the matter of a concrete, several particles of that matter are reduced to a shape and size, requisite to compose such a liquor as the chemists call phlegm or water. *Scept. Chym.* See farther in the article of *Water*.

† The name *spirit* is applied by the chemists to several very different substances: it denotes in the general, any distilled, volatile liquor, that is not insipid as phlegm, nor inflammable as oil: but under this general idea, are comprehended liquors of quite opposite natures, some being *acid*, as spirits of nitre, salt, and vinegar; and others *alkalious*, which are such enemies to the former, that as soon as they are put together, they tumultuate and grow hot: To which may be added a third kind, call'd *vinous*, or inflammable, which tho' very subtle and penetrating, are not manifestly either acid or alkaline.

All these sorts of spirits Mr. Boyle shews to be producible: and 1^o, The *vinous*, which nature scarce ever produces of herself; fermentation being requisite thereto. 2^o, *Alcalous* spirits call'd also *vinous*, by reason of their affinity in many qualities with spirit of urine, are manifestly not simple, but compound bodies, consisting of the volatile salt of the respective concretes

dissolved in the phlegm, and for the most part accompanied with some little oil; so that these may be referr'd to the article of volatile salts. 3^o, *Acid* spirits appear to be producible hence, that those drawn from common salt and nitre, are very different in respect of taste, &c. from the bodies they are procured from, which are not properly acid: so that it does not appear, that the spirits pre-existed in that state, in those bodies. What further confirms the whole, is, that the same body, merely by different ways of ordering it, may be brought to afford either acid, vinous, or urinous spirits. *Boyle Scept. Chym.*

Add, that whereas salt is laid down as the principle of all taste; and bodies are argued to be *saline* for this reason, that they are *sapid*, 'tis implied in the very notion of a spirit, that it have salt along with it; it being its taste that characterizes, and distinguishes it from phlegm, and denominates it acid, vinous, or urinous spirits. *Boyle's scept. chem.*

Asto mercury, which is spoke of by chemists as a principle, near a-kin to spirit, or rather is confounded therewith: its characters, as delivered by writers, are, to be a fluid substance, or volatile liquor, which distinguishes it from the saline principle, especially fixed salts; and not inflammable, which distinguishes it from sulphur or oil. But, as this leaves it undistinguished from phlegm; others add another quality, viz. taste, which is wanting in phlegm, which brings the chemical mercury precisely to what we call a spirit. The *mercuries* of vegetables and animals, therefore, are already spoke of as *spirits*.

The

Salt.

3°, *Salts*, tho' they seem perfectly simple, yet when rectified, yield either an acid, or an *alcohol*, and *phlegm*; and if the distillation be repeated, do still become purer, and purer, leaving every time a quantity of oily *fæces* behind 'em; and at length, losing all their saline quality, become insipid. Thus, salt of tartar, which by a violent combustion in the fire, an intimate solution in water, and a filtration, should seem perfectly purified; yet if it be dissolved *per deliquium*, leaves a large earthy sediment: and if the oil of tartar, thus prepared, be dried again, and the salt-juice be calcined, and suffered to dissolve again *per deliquium*; it will leave still more earthy *fæces*. And if the operation be repeated a good number of times, the salt will at length be all converted into earth.

All salts consist of fix'd, and volatile parts; and human salts, particularly, resolve, by distillation, into an oily spirit, and earth: nor does it appear, that the chemists ever get a salt quite clear of oil; for all volatile salt has some smell; but that smell arises only from the oils therein*.

4°, *Oils*,

The mercury of fossils, or metals, is no other than a real running quicksilver; which is a fluid substance, perfectly resembling a metal in fusion, nearly of the same weight with silver, and wetting no body but gold. This body not being reducible into more simple matters, by any analysis yet invented, is look'd upon as a principle: 'tis commonly held it may be extracted, or obtained from all metals and minerals. And the chemists, in their writings, give us divers processes for the same; tho' the more judicious, and sober among them, have long look'd on the pretension as idle, and chimerical.

But this principle, *mercury* or quicksilver, M. *Homburg* gives us sufficient reason to suspect not to be simple; in that it may be destroyed, which a body perfectly simple cannot. Add, that after its destruction, there remains nothing but a mere earthy matter, without any signs of the other parts before compounded with it. The method that author took to destroy it, was by first changing the running mercury into a perfect metal, gold, by introducing a sufficient quantity of the rays of light into its substance, by a long and expensive operation; and when it was thus rendered a metal, by exposing it to a burning glass, which in a little time carried off the greatest part of its substance in fumes, leaving nothing behind but a light earthy dust. *Mem. de l'Acad. R. An. 1709.* See further under the article *Mercury*.

* *Salt* seems the leading principle of the chemists, who generally grant salts the most considerable and active parts procurable by chemistry from mixt bodies. Its character is to be soluble in water, and unresolvable by fire; but, under this character it is incapable of being perceived by us; and needs to be joined or combined with some other principle, to make it sensible.

We have three kinds of salts, two whereof are volatile, and the third fix'd; the volatile are *acid* and *urinous* salts, the fix'd *lixivious*, or those drawn from ashes: the two latter are also call'd *alkalious* salts, or *alkalies*, the one volatile, the other fix'd. We do not know the precise figure of each of these salts; but to judge of 'em from their effects, the most commodious and probable, according to M. *Homburg*, the great reformer of the doctrine of salts, is, for *acids*, to be pointed, and those points tipped with sulphurous matter; that of *urinous* seems to be a sponge, containing a part of the acid, and a little foetid oil; that of *lixivious* salts, appears likewise, a sponge, containing only the remainder of the acid, which the calcining fire could not carry off.

1°, If *acid* salts were found pure, and without any mixture, they would all be of the same nature; and the diversity that appears in 'em, as procured by distillation, &c. is a full proof of their being compounds, at least of their having something

4^o, *Oils*, by distillation resolve into an *oil*, an *acid salt*, and *water*; and the oil distilled ever so often, does always leave earth behind it; so as, at length,

thing heterogeneous, or adventitious to the saline nature accompanying them. In effect, sulphur, on M. *Homborg's* principles, is a constant and inseparable attendant thereof: from this appendage of sulphur, it is, that they derive all their activity; and 'tis the same sulphur that characterizes, and makes the difference between 'em. Hence acid salts are rang'd by the author, into three classes, viz. such as contain an animal or vegetable sulphur; under which come all the acids distill'd from plants, fruits, woods, &c. and spirit of nitre: such as contain a bituminous sulphur; to which belong the acid salts of vitriol, common sulphur, and alum; and such as contain a more fix'd mineral sulphur; as the acids drawn from sea salts, and sal gems.

Those of the first class, act more swiftly than those of the other, by reason animal, and vegetable sulphurs being very light, i. e. taking a deal of room, and enlarging the surface, give the better handle to the flame to agitate and drive 'em on; but the same enlargement of the points, prevents their entering into the denser and more compact bodies: those of the second class are the least nimble, by reason the bituminous sulphur is loaden with a deal of earth, which serves it as a matrix; and accordingly, these are incapable, singly, of dissolving metallic bodies. Lastly, the metallic sulphur, being the most fix'd, i. e. its parts the smallest and most compact, the acids it accompanies, do still retain fine points, and thereby become capable of insinuating into the densest bodies, and separating 'em: tho' for the same reason they give but little hold to flame.

Acid salts join'd with *lixivious* ones compose mix'd or intermediate salts, according to the nature of the acids employ'd therein. V. gr. spirit of nitre, with salt of tartar, produces true salt-petre; spirit of salt, with salt of tartar, produces true common salt; spirit of vitriol, with salt of tartar, produces true vitriol, &c. which are all intermediate salts, i. e. partly fix'd, and partly volatile, the two ingredient salts still retaining their volatile and fix'd

natures. *Acids* join'd with *urinous* salts, compose another sort, call'd *ammoniac* salts, which are always volatile, by reason both the ingredient salts are so. *Acid salts*, are usually supposed to be antagonists to *alkalious*, (i. e. *urinous* and *lixivious*) by reason, upon their mixture, there always ensues a violent ebullition, and effervescence; but it would, perhaps, be more just to look on this ebullition not as a combat, but rather a suitable and amicable conjunction of two substances, which were naturally united, and had only been separated by the violence of the fire, now restoring themselves into the same places, out of which they had been torn. Accordingly, the latter are compared to sheaths, and the former to points or spicula fit to enter the same. These points or acids do not only enter the pores or sheaths of alkaline salts, but all other bodies, whose pores have a like conformation; whence such bodies are call'd *terrestrial* or *metallic alkalies*. *Mem. de l'Acad. An. 1702.* See more on the subject of acid salts, in the article *menstruums*.

2^o, In all native salts, both fossil, vegetable and animal, after the violence of the fire has separated all the volatile parts, there still remains a *fix'd* salt, to be drawn from the faces by lortion, or lixiviation; hence call'd a *lixivious* salt. These *lixivious* salts are no other than the relics of the *acid*, which the fire was not able to separate from the earth of the mixt, but may be separated by dissolving 'em in common water. The taste of these *lixivious* salts is very different, according to the quantity of the acid still remaining after calcination: part of which is capable of being volatiliz'd, and disengag'd by further operations; as by a more intense heat; or by dissolution, digestion, filtration, and evaporation frequently repeated; or lastly, by adding some *urinous* salt, to absorb the same.

3^o, We have three sorts of *urinous* salts: the first, that of plants, or animals, which is the same; the second is fossil; and the third of an intermediate kind, partaking both of

of the fossil and vegetable nature; the first is volatile, and the two latter fix'd. By *urinous* salts, we mean all such as partake of the taste or smell of urine. Their effect in volatilizing fix'd salts is notorious: for being added to common salt, there arises, by fire, a salt of a volatile kind, called a *sal ammoniac*. Tho', for volatilizing the fix'd salts of plants, the urinous salts of plants are not so proper as the urinous salts of the intermediate class, such as *alum*: and for the fix'd salts of fossils, the fossil urinous salt is fittest, viz. *borax*. *Homb. ubi supra.*

All the sorts of salts, then, do throughout, appear, avowedly compound, and unelementary: and that they are likewise producible, *de novo*, and convertible into one another, is strenuously argued by Mr. Boyle. The two chief qualities, wherein they all agree, and which therefore make up the common received notion of salt in general, he observes, are to be easily dissoluble in water, and to affect the palate so as to cause a sense of taste. Now, since the invisible particles, which compose the visible portions of a salt, may be so contriv'd as to make other parcels of matter, which have the qualities that denominate bodies *sulphurous*, or *spirituous*; as we see in nitre's being made inflammable: why may not other corpuseles, or small portions of matters not saline, be so broken into minute parts, and these so shaped and connected, as, when duly associated, to compose a body capable of dissolution in water, and of affecting the organ of taste.

That a disposition to be dissoluble in a liquor, may be acquired by mixture, and a new texture of parts, appears from many instances: and as for the taste, 'tis some question, how far the necessity thereof may consist with another principle; for the purest oils are sapid, yet will not dissolve in water; so that there does not appear any strict connection between being *sapid*, and *soluble* in that fluid. *Helmont* assures us, that by *Paracelsus's sal circulatum*, solid bodies, among which he instances stones, may be transmuted into actual salt, equal in weight to the body whereof it was made; consequently, as the chemists allow of sulphur, mercury, &c. in such bodies, it appears, that the same

portions of matter, which pre-existed in the form of those simple ingredients, must, by the operation of fire, and the menstruum, have been converted into salt.

For *acid* salts; we may instance in *salt-petre*, which, tho' it have no acid taste, may be made to afford, by distillation, above three quarters of its weight, of a highly acid liquor; yet it does not appear, that such a great proportion of acid particles, or possibly any proportion at all, is employed by nature, in the composition of nitre.

For *urinous* salts, we have an instance of their production, in the salt, obtained by distillation, from soot; for tho' the wood we burn in our chimneys, seem to have nothing of the taste or smell of urine; nor have the dissolutions of the saline parts of such wood, been observ'd to have any affinity, in taste, or odour thereto; yet when wood is burnt in the fire, and the soot afforded by it distill'd, we get a white volatile urinous salt, like what is afforded by blood, urine, or the like.

For *lixivious*, or the *fix'd salts* of calcin'd bodies, the chemists themselves are not entirely agreed. For however the prevailing opinion may be, that these fix'd alkalies pre-exist in mix'd bodies; *Helmont* very ingeniously proposes another origin, and holds 'em, as to their alkaline form, productions of the fire, by whose violent action, a part of the salt, which in the concrete, is all naturally volatile, laying hold of some parts of the sulphur of the same body, both become melted together, and thus fix'd into an alkali: which fixation he exemplifies, by what happens when *salt-petre* and *arsenic*, tho' both volatile, when exposed to the fire, are, by its operation flux'd and made to fix each other: tho' what seems to overthrow this account, is, that the fire may not perhaps be always found a necessary agent, in the production of a *lixivious alkali*: for Mr. Boyle tells us of a piece of true native *Egyptian nitre*, which appeared to have all the properties of a fix'd alkali. That author pursues the point further; and shews how to make alkalies from sea-salt and salt-petre, tho' confessedly acids; how alkalies may be deprived of their alkaline form, and turn'd into other substances; how common salt may be procured from sandever, a fix'd alkali, &c. *Producib. of Chem. Princip.*

length,

length, it all becomes earth *; as Mr. Boyle assures us from experiments ; and

* The chemists lay down inflammability as what characterizes their principle *sulphur*: whence it happens, that three substances, manifestly different in consistence, and texture, come necessarily to be referr'd to sulphur: the inflammable substance, obtained from mixt bodies, by means of fire, appearing sometimes in form of an oil, which will not mix with water; sometimes in form of an inflammable spirit, which will readily unite with that liquor; and sometimes in form of a consistent body, not unlike fossil sulphur. Now, what in most mix'd bodies is call'd *sulphur*, need not be conceived as any primordial ingredient, but rather as a generated and resulting thing: for sulphur it self is made of the same universal matter with other bodies; and is only a coalition of certain particles thereof, whose aggregate, by having a particular texture, &c. becomes disposed to be turn'd into fire, and usually also into flame; and therefore if the like texture may be found in portions of matter, in other respects different, or if art and chance can frame, and bring together particles of matter so disposed, or can give 'em such a texture as disposes 'em to kindle, flame, or burn away; these qualifications entitle it to the nature of a sulphur, whether it participate of the chemists primæval sulphur, or not.

And, that it is not necessary the oil, procured by fire from mixts, be a primæval element, may be argued from the growth of plants, fed merely by water; which nevertheless afford an oil in distillation: and we see that in olive trees, almond trees, walnut trees, &c. the rain water, which insinuates it self into their roots, is, by successive changes of texture, reduced into the oil, which the fruit, by expression, so plentifully yields. And to obviate the suspicion of common water being impregnated with any sulphurous juices of the earth, it may be added, that distill'd water will nourish a vegetable. What is more, Mr. Boyle relates an experiment, whereby from two distill'd liquors, both dissoluble in water, and both held by the chemists, as elementary bodies, viz. oil of

vitriol, and alcohol of wine, he procured a considerable quantity of chemical oil, of a very different nature from either of the ingredient liquors. *Producib. of Chym. Prin.*

This oil, or sulphur, of vegetables and animals, is, according to Helmont, reducible, by means of lixivious salts, into soap; as that soap is, by repeated distillations from a *caput mortuum* of chalk, into insipid water. *Id. Sect. Chym.*

For the production of that kind of sulphur call'd inflammable spirits, it has already been touch'd on, in speaking of spirits. For that of consistent sulphurs, it does not appear, that any such substance is really procurable, either from vegetables or animals: what the chemists have usually taken for vegetable sulphurs, Mr. Boyle shews to be no other than fossil sulphurs, and to be separated, not from the matter of the vegetable, but from that of the fossil matters used in the process. And as for the sulphurs sometimes obtain'd from metals, and minerals, 'tis much to be doubted whether they belong'd thereto, as essential ingredients, or were only corpuscles of common sulphur, perhaps, a little alter'd, and mingled with other parts essential to the mineral. Thus we see in native cinnabar, the mercury, which chemists suppose a compleat metal, is so mix'd with another body, as not to be distinctly discernible, till separated by the fire: and from this cinnabar, sulphur has been sometimes obtain'd. Add, that as a large quantity of common sulphur is easily separable from vitriol marcasites; it appears possible for some common sulphur to remain more closely mix'd with the saline and metalline parts of the vitriol, afforded by the same marcasites; from which latent corpuscles may proceed the sulphurous smell, &c. observ'd in vitriol and its oil. See Boyle's *Producib. of Chym. Princip.*

M. Homberg refines considerably on the notion of the principle *sulphur*. That oily, or fatty matter, found in the analysis of all plants, and animals, and some minerals, and which has been always taken for the chemical principle sulphur, cannot be a principle, on his foundation; since it may

B b

be

and as we our selves have found from a like experiment, made in oil of *guaiacum* †.

Salt

be reduced into other simpler matters. Add, that as he lays down the principle sulphur for the only active one, and which of consequence should be found in all mixts; this oily matter is wanting in most minerals, and therefore cannot be the only active principle. In the analysis of an oil, its whole substance resolves into a deal of aqueous liquor, a little insipid earth, and a little salt, partly fix'd and partly volatile; the real principle sulphur, which connected these principles together to make an oil, is lost in the operation; the whole study of the artist being only to separate the principles from each other. And as the principle sulphur is only sensible while join'd with some other of the principles, which serve it as a vehicle; it must of necessity escape from whoever would strip it of all heterogeneous matter.

This sulphur may either be consider'd as mingled, and retain'd in some other matter; which, as it is aqueous, saline, earthy, or mercurial, the result will appear under the figure of spirit of wine, oil, bitumen, or metal; none of which are the principle sulphur: or, it may be consider'd as pure, and without any mixture; in which last sense alone, it is, that sulphur is to be accounted a principle, and the only active principle; leaving to the rest the appellation of sulphurous matters. Now, all mixts, that excellent author observes, in passing a rigorous analysis, lose the principle sulphur, which was the band of the composition; so that the more the chemist endeavours to extricate, and disengage it, the less he finds it.

† *Earth*, by the chemists call'd *terra dampnata*, of all substances seems to have the fairest claim to an elementary nature; in regard the violence of the calcining fire should seem to have driven away all the mercurial and other volatile parts, and have quite burnt out the sulphurs, which are often more fix'd than the rest; as the water, on the other hand, should have dissolved all the fix'd salt: and yet, as to the characters, whereon the simplicity and immutability of the earthy part of

bodies are supposed to depend, *v. gr.* its not dissolving in water, its not affecting the taste, and not having flown off with the other parts; it will be found that these too, are producible, may be compounded, &c.

Mr. *Boyle* has shewn, that not only each of these qualities separately, but all of them together, may and frequently do, arise from the mixing and variously managing of compound substances, wherein before they were not. Thus from oil of vitriol, and spirit of wine, tho' both dissoluble in water, and sapid, he has, by digestion and distillation, procured a large quantity of a substance indissoluble in water, insipid and fixed. So also glass, which tho' not only a compounded, but a recomposed body, (the sand, and other stones, which themselves are mix'd bodies being further compounded with the salts that dissolve them) has yet all the three qualities, which the chemists require in their earth; for 'tis tasteless, dissolves not in water, and is fix'd in the fire. And if ashes be of themselves capable of vitrification, as the chemists teach; how are we sure, that in common ashes, freed after the usual manner, from their fixed salt, what is called a simple earth, may not be a body compounded of two, or more substances, which by their collision, and new texture, produced by the action of the fire, have been brought to a kind of vitrification?

That earth may be produced *de novo*, may likewise be argued hence, that if salt of tartar be dissolved in fair water, there will remain, after numerous filtrations, and after every single one, a substance in the filtre, which has all the chemical characters of earth. The *terra dampnata* of vitriol appears evidently no elementary body, from its purplish colour, its weight far exceeding that of earth, &c.

In effect, in some bodies, particularly those of the metalline kind, the calcining fire does not operate as in others, particularly vegetables; since sometimes almost the whole weight of a mineral shall be found in what they call its *cals*; as we see in tin calcined *per se*: which *cals*

Salt, water, oil, and earth, when pure, seem to be the same in all bodies: and all the difference in such bodies, arises from a spirit, which resides in the oil, and is thence denominated the *rector*, or *archaus*. Distill, e. gr. cinnamon and wormwood as long as you please; and you will have water, spirits and oils, that have the several tastes and smells of cinnamon, and wormwood: then, burning what remains, you will have salts, and earths, in all respects alike. But the odorous water abovementioned, in time lays aside its oil, and becomes insipid in both; or, if it be expos'd to a gentle fire, the spirit all exhales, and leaves it vapid: whence it appears, that the difference lay wholly in the oil. Now, pour some of the oil on the water thus effete, and beat 'em stoutly together, and you will have the odorous waters of the plants again. Or pour on fresh water, till at length it undergo no alteration, and you will have oils perfectly alike; i. e. the oil of cinnamon, and that of wormwood, will be of the same kind. Whence, again, it appears, that the *spiritus rector* is the cause of all the difference. Add, that to whatever this spirit is join'd, whether to oil, salt, earth, or water, you will in each have all the strength, and virtue of the plant.

Tho' bodies are not resolvable by chemistry into any simple, immutable elements; yet they all terminate in a certain number of principles //

From *vegetables*, e. gr. are drawn five; viz.

1^o, *Water*, 2^o, *Spirit*, which is nothing but oil so attenuated as to be miscible with water; 3^o, *salt*, 4^o, *oil*, 5^o, *earth*.

From *animals* are drawn a like number of principles; between which, and those of *vegetables*, there is scarce any difference; except, that the salt of animals is volatile; and that of *vegetables* fix'd; and that the latter yield an acid salt, which the former do not †.

is in great measure reducible sometimes into a body of the same nature with that which afforded it; and sometimes into another body, far from being elementary: as in the reduction of minium into lead, ashes of antimony into glass, &c. See further in the chapter *earth*, as an instrument.

|| As vigorously as Mr. Boyle combats the elements, yet he allows, 1^o, That many mineral bodies may be resolved into a saline, a sulphurous, and a mercurial one; and that almost all vegetable and animal concretes, may be reduced, by fire, into five substances, salt, spirit, oil, phlegm, and earth; of which the three former being more operative than the two latter, may be look'd upon as the three active principles, and by way of eminence be call'd the three principles of mixt bodies. 2^o, That these principles, tho' they be not perfectly simple, may, without inconvenience, be filed the elements of compound bodies,

and bear the names of those substances which they most resemble, and which are manifestly predominant in 'em; because no one of these elements seems divisible by the fire into four or five different substances, like the concrete, whence it was separated. 3^o, That several qualities of a mixt body, and especially the medicinal powers, do, for the most part, lodge in one or other of these principles. *Sept. Chym.*

† It is remarkable enough, that the order wherein these principles succeed each other is different, according as the mixt has undergone a fermentation or not: if it have, the spirituous liquors, and volatile salts rise first, then the aqueous liquors, then fetid oils, leaving a *caput mortuum* at bottom, which affords a fix'd salt and earth. If it have not fermented, the aqueous liquor precedes the volatile salts, and spirits; the other matters following in the order abovementioned. *Homburg, Mem. de l'Acad. R. An. 1702.*

As to *fossils*; some of 'em, we have already shewn, are resolvable into two, and others into three principles*.

* That accurate chemist, M. Homberg, in his new *Essais de Chemie*, lays down the principles of fossil bodies to be salt, sulphur, mercury, water and earth: not that all fossils contain 'em all; for mercury, he shews, is not a common principle: but some have it, as metals and metallic minerals; and others not, as stones, earthen, fossil salts, &c. The principles of all animal and vegetable bodies, according to the same author, are salt, sulphur, earth and water. *Mem. de l'Acad. An. 1702.*



THE

THE EFFECTS, or PRODUCTIONS, OF CHEMISTRY.

THE chemists, by separating, and uniting, resolving and com-
pounding bodies, produce an infinite number of effects; all which
may be commodiously enough reduced to four general classes: viz.

Magisteries, Extracts, Elixirs, and Clysters.

Magistry is a name given by the antient chemists to the master-piece of
their art; which is a change of the form of any body, in all its parts, without
making any alteration in the quantity thereof. Or, a magistry is a body re-
duced into another body, yet all its former substance retained. Thus Paracelsus:

"If you have the matter of gold, and know how to prepare it, so as in
"one moment to render all that gold a potable liquid; it is a magistry of
"that thing. Or if you can convert mercury, or silver, or gold, into its
"ens primum, or radical liquid;" that is, if you can penetrate its whole,
intimate substance, and render it potable, by the admixture of a *menstruum*,
which shall resolve whatever was coherent in the body, "it is a magistry."

Consequently, magisteries require the alcahest, or universal dissolvent.

But the apothecaries, and less knowing among the chemists, apply ma-
gistry to any considerable change of a body into another form; particular-
ly to certain powders dissolved by *menstruums*, and precipitated. Thus
if you take an ounce of pearls, and dissolve it in one or two ounces of spi-
rit of vinegar, and then cast in salt of tartar to precipitate the solution;
the powder of pearls, before sustained in the vinegar, will be now found
at the bottom of the vessel; which powder is perfectly the same with the
body or substance of the pearls: and this powder, when wash'd, is call'd
magistry of pearls.

A magistry is distinguish'd from an extract, and an elixir, in that, in the
latter there is a separation of parts; some being taken and others left behind.

2º, *Extract*,

Extract.

2°, *Extract* is the pure, and efficacious part of a body, separated from the less efficacious parts, by means of some liquor, or dissolvent. Or, an *extract* is a chemical effect, perform'd in a single body, by *separating*, and *extracting* the homogeneous parts thereof, without *changing* 'em: thus, if you have mercury, and from this mercury separate the corrosive sulphur; this sulphur, thus separated, is call'd the *extract of mercury*.

And hence, all *tinctures* are *extracts*. But it is to be carefully noted, that in *extracts*, the parts are to be actually separated; for if they be compounded together, and so both changed, it is denominated an *elixir*.

Elixir.

3°, *Elixir*, according to the antient chemists, and physicians, is an essence, or rather magistery, of several bodies join'd together: thus, *e. gr.* if I take aloes, myrrh, and saffron, of each an equal quantity; and by digestion reduce those three into one potable form; it is call'd an *elixir*: if I only took one of those ingredients, *e. gr.* saffron, it would be a *magistery*.

An *elixir*, therefore, is a compound magistery, *i. e.* a composition of various bodies, chang'd after the same manner as a single body is, in a magistery.

Yet some authors use *elixir* for a sort of compound extract; *i. e.* a tincture or essence, drawn from several bodies combined together: as if from worm-wood, sage, and euphorbium, blended together, a tincture be drawn by means of some menstruum.

Clyffus.

4°, *Clyffus*: in this the three former *effects* are united: thus, if you have four or five bodies, and from each of 'em draw a tincture or extract; and mix these together, it is called a *clyffus*. Take, *e. gr.* aloes, saffron, and myrrh, and pour spirit of wine upon 'em; this will draw out the resinous substance from the myrrh and aloes, and the subtile oil from the saffron; leaving the fæces at the bottom. This, some call an *elixir*, but inaccurately; for an *elixir* is only a mass of all the ingredients; but a *clyffus* an extract from 'em all.

Others make the *clyffus* to consist of a number of the efficacious principles, drawn from one and the same body, purified, and then recombined, or mix'd again: as when the several species of the same thing, separately prepared, are united again; *e. gr.* salt, sulphur, oil, spirit, and mercury, are again brought to coalesce into one body.

THE
END and USES
OF
CHEMISTRY.

WE said in our *definition*, that *chemistry* was an *art*; and consequently it must regard some certain *end*. End is defined by the schools, That which is first in the intention, and last in the execution; or it is that which excites the mind of the artificer to the use of certain means whereby a thing is accomplished. All arts have such an end as this; and they are exercised merely for the sake of it. The end of chemistry appears from the definition we laid down thereof; wherein that art was said to *change* sensible bodies, so as to discover their several powers, or virtues, &c. But all bodies act according to what they are, and not according to what they were, or shall be: Consequently, since chemistry renders the present effects of all bodies, sensible, we cannot be at a loss to discover its end; tho' that may be various, according to the views of the operator, or its exceeding usefulness in all the parts of natural philosophy; as might be made fully appear by a long train of particular instances.

Various are the uses of chemistry; and there is no art whereto it may not be subservient, and assisting. 'Tis very difficult, therefore, to ascertain all its particular uses; because, being the largest branch of physics, 'tis concern'd with all manner of natural bodies, more particularly with fire, the most universal of them all.

Uses

*Uses of Chemistry in Natural Philosophy.**Natural philosophy, what.**Taught by chemistry.*

Natural philosophy, that is, the history of the existence, phenomena, and operations of natural bodies, consists of two parts; the one *experimental*, which nakedly proposes the phenomena of bodies; the other, *argumentative*, which, from the phenomena observ'd, draws new conclusions, by reasoning upon them with geometrical exactness. And as there is no way to discover the actions of bodies, but by experiments; chemistry, which deals entirely with these, must needs be exceedingly useful in natural philosophy. 'Tis by chemical experiments that we learn the actions of one body upon another; and the effects produced by those actions; that is, in other words, the powers and laws of nature.

All the natural bodies existing, may either be in action, or not in action; for, from the passive principle, as 'tis called, or force of inactivity in them, they are indifferent to motion or rest; and we can never know, otherwise than by experiment, which of these two states a body is in. Bodies act not by their corporeal nature; but by a certain further property super-added to them, when created, which determines them to action*. But the principles of their action are either common to them all, or peculiar to some of them. By the former, we can never fully explain the various changes and phenomena of bodies. Who is there, that from the extension and solidity of the load-stone, could say, it must necessarily attract iron? We are, therefore, as natural philosophers, to discover the particular powers inherent in particular bodies; which can never be done without a solicitous and experimental scrutiny into their nature and actions.

There are two ways, according to the great Lord *Verulam*, whereby natural things become known to us; that is, we may designedly search after them by experiments; or they may casually offer themselves to us without inquiry. Chemistry must necessarily be exceeding fruitful in both; since all the productions of the three kingdoms are, as we have already shewn, its subjects. The latter of these two ways is, in reality, chemistry itself; and, accordingly, all the philosophical experiments made with any view or design, have been derived from that art. Hence, we plainly see,

* Body being absolutely passive, there is a necessity for some active power or principle to put it into motion, and make it produce the phenomena it affords. Body at rest is not only incapable of acting, but even carries an opposition to action: It has a real power of inactivity, a *vis inertia*, as we call it; which removes it even out of a state of indifferency, and determines it absolutely to remain inactive: So that not only a contrary power or principle, but that even in a higher degree than the former, is necessary to produce action therein.

The active powers which have hitherto fallen under observation, are gravity, whereby bodies tend toward the centre; attraction, whereby the particles of bodies cohere; the causes of elasticity, electricity, magnetism, fermentation, &c. See this point further consider'd in the notes on the chapter *Of Operations*, p. 171, 172, &c.

'tis the general end of chemistry to shew the conditions of the bodies which exist, observe their changes, and remark the effects they produce.

'Tis chemistry which shews us philosophy in action, as the Lord Bacon ^{And that practically, or experimentally.} justly observes: All the antient philosophers were very busy in explaining nature by words; but chemists alone are practical philosophers. 'Tis they, for instance, who understand heat, with the nature thereof, so as to be able to produce, exhibit, and apply it to numerous purposes. Bid a chemist convert gold into glass; and, by means of a burning concave, or otherwise, he presently does it. Ask him to shew you gold in powder; and, by mixing a little antimony with that metal, he will soon render it pulverable. Thus, speculative philosophy is made practical by chemistry; which, at the same time that it explains things, actually exhibits them to the eye. And this is the philosophy so much recommended by the sagacious Verulam.

We must own, indeed, that no art has been more prejudicial to natural philosophy than chemistry, whilst it was not confined to observations alone, ^{With what caution to be applied.} but called in the assistance of uncertain reasoning: as, on the other hand, nothing was ever more advantageous to the same, than genuine chemistry, whilst it went no farther than experiment. A chemist, therefore, should content himself with experiments alone; unless he can, with mathematical rigour, draw just conclusions from the phenomena he observes. Hence it appears, that whoever would procure an exact history of nature, must be first acquainted with mechanics, which gives us the general properties of matter; and, in the next place, understand chemistry, which explains the ^{Its nature,} particular qualities whereby bodies act upon one another. Each of these is insufficient without the other: A mere mechanic could never, from general properties, deduce the surprizing effects of gun-powder; and a mere chemist, who might do this, would make but a wretched philosopher, if ignorant in mechanics; because, from some particular powers, he would ridiculously attempt to explain all the motions in nature.

'Tis from chemistry that we know, all the actions of bodies proceed not ^{And doctrine} from any plastic spirits, or substantial forms; any dæmons, or sprights; with which the superstition of some enthusiasts hath fill'd the world; but principally from the never-ceasing motion of fire: and that all these actions depend upon mechanical principles; as Mr. Boyle, from the art we are speaking of, has excellently and amply shewn*.

* It is by means of chemistry, that Sir Isaac Newton has made a great part of his surprizing discoveries in natural philosophy; and that curious set of queries, which we find at the end of his optics, are almost wholly chemical. Indeed, chemistry, in its extent, is scarce less than the whole of natural philosophy; as might be satisfactorily shewn by a thorough chemist; after the manner wherein our learned author proceeds to shew, that almost the whole of medicine is chemistry.

*Uses of Chemistry in Medicine.**Medicine, what.*

Medicine is that small part of universal physics, which demonstrates by what laws the motions in a human body are perform'd ; and aims at nothing more than to discover the natural state thereof, with the alterations whereto 'tis liable from what it receives, whether as food, physic, or poison ; whereby it is determined either to health or sickness : and, consequently, this art has the human body for its object ; which, consisting of the same principles with all other bodies, tho' put together after a different manner, 'tis plain, from what we have said of the usefulness of chemistry in natural philosophy, that it must be greatly serviceable to physic also. But, to manifest this the more fully, we will point out its use in the five several parts whereof the art of medicine consists.

*Usefulness of
chemistry in all
the parts there-
of, viz. physio-
logy.*

1. *Physiology* borrows most of its light from chemistry. By physiology we mean that part of medicine which explains the nature of the entire animal machine, consider'd in its natural state, when its operations are perform'd in greatest perfection ; or in a state of health ; which depends upon a just balance of the solids and fluids. This part of physic, therefore, instructs us as to the matter of the human body, the cohesion of its parts, whether solid or fluid, their consistence, elasticity, figure, reciprocal actions upon each other, &c.

In the matter of a human body, mechanics can make no great discoveries ; but chemistry will shew us, that all the solids which go to compose it, are either mere earth, or some earthy substance, held together by a certain attractive force, or by a particular oil ; for every solid part, when urged with fire, leaves nothing but earth and oil behind it. And hence we learn why the vessels of our bodies are not, as water, spirit, oil, or salt would be, set loose, and render'd volatile, by the heat they naturally sustain ; or the other powers that continually act upon them : namely, because they are composed of an earth that is not to be changed by any substance, or operation in nature.

Again, no-body but a chemist could say what kind of liquor the blood is, of what parts it consists, and by what principles it acts ; for it does not act solely as a fluid, flowing along its canals, according to the laws of hydraulics ; but, at the same time, exerts a force of its own ; which chemistry explains, by shewing it possessed of certain active principles, as salts, spirits, oils, &c. wherein it differs from other liquids : and, by knowing the particular nature and quantities of these, a chemist will nicely understand, and advantageously distinguish between the signs of health and sickness.

Indeed, nothing but chemistry can shew how bodies excited by a particular degree of motion or heat, must needs cause such and such changes, or produce such and such effects. Suppose an ox to feed wholly upon grass, and to drink nothing but water, for the space of ten years ; if as much grass as was eaten by the ox but in one of those years, were burnt, it would

would afford a large quantity of fixed salt; yet, if at length the ox himself were wholly burnt, not a grain of fixed salt would remain in the ashes. There is, therefore, a certain power in animals, whereby all the substances they take in, are changed in their nature; tho', without chemistry, 'tis impossible to know what kind of power that is. But this art, by shewing us that the heat which is always present in an animal body, can render all oils and salts volatile, directly solves the problem. And this is the case not only in physic, but in all the other parts of natural philosophy; for chemistry will teach us what must every where happen in the whole, or different parts, of the same or different substances, from different degrees of motion and heat.

2. *Pathology* is inexplicable by any thing but chemistry. 'Tis the office ^{Pathology.} of this part of medicine to *unravel and describe the distempers incident to the human body, and to assign their nature, causes, effects and differences.* If *Hippocrates*, therefore, had understood chemistry, he would have been infinitely a better physician than he was. All that he could do in this part of his profession, was only, with diligence and accuracy, to observe the phenomena of diseases; which might let him into some knowledge of their nature, after he had spent much time in this way: but all his care and pains could never once inform him of the state of the solids and fluids, from the beginning of the distemper to the end of it: He must absolutely be a chemist, who would know how these are alterable by heat; and here the skill of *Hippocrates* failed him. He knew not, in a burning fever, for instance, that the salts of the body were dissolved, and the oils render'd volatile. That great author, therefore, tho' well versed in the phenomena of diseases, knew but little of their real nature.

No physician can, with the least shew of probability, account for the rarefactions, obstructions, concretions, &c. in the human body; nor for the corruption of the fluids thereof, without the assistance of chemistry. The very notion of corruption implies a separation or change in the nature of all the salts and oils of bodies; for these, being now attenuated and exalted, gain a caustic quality; the salt, which was before mild, and somewhat indisposed to volatility, becoming volatile and corrosive; and the oil, which before was gentle, viscid, and harmless, proving violently sharp, rancid, and volatile. But by comparing the writings of the antient physicians with our chemical philosophy, we shall find that none of them spoke to the point about putrid diseases. They assigned for the cause of these a bilious matter, and a melancholy humour; words which carry no meaning: but chemistry examines the humours putrefied in the body; compares them with the same humours, included for the same time in proper vessels, and exposed to the same degree of heat; whence it exhibits the very same effects as, in this case, are found in the human body. And it is this art alone, that can putrefy humours to any assigned degree; and, consequently, this alone can teach what must ensue upon a stagnation of the blood in the body, according to the particular parts wherein it happens; and what will be the effects of particular motions of that fluid. Thus, we can now, from chemistry, certainly foretel, that a strong circulation

lation will heat the body too much, render it dry, throw off its finer parts, amass the grosser together, render all the salts and oils volatile; and hence explain numberless the like phenomena, which none but a chemist could possibly account for. And hence it proceeded, that the antients never knew how a caries of the bones happened, nor how to cure it; but chemistry informs us, that the bones become carious from a putrefaction or corruption of their marrow, whereby it is render'd so sharp, as to corrode their substance: and the same art instructs us to stop the growing mischief, by the application of a very strong and penetrating lixivium. If it be said, that still the antients understood putrid distempers; I grant it as to their effects, and visible appearances; but not at all with regard to their causes: and therefore they never distinguished between them, nor gave any rational account thereof.

Semeiotics.

3. The *semeiotical* part of physic, or the doctrine of signs, is principally concern'd about the pulse and urine. Now, all the changes in bodies must proceed from causes: and when any change is observable, 'tis called a phenomenon, and must needs be the effect of some cause or other; but the cause always lies deeper than the effect; yet is often discoverable by means thereof. Whatever leads to the knowledge of this cause, we call a sign; and the art of discovering distempers by such signs, is term'd *semeiotics*. Whence it appears, that chemistry must be exceeding useful in this part of medicine also. Suppose, for instance, a chemical physician should find his patient hot and inflamed, his urine red, and his pulse quick and hard; he will from hence immediately know the state of his fluids, and be aware that they tend to a state of putrefaction.

The antients, as particularly *Hippocrates* and *Galen*, would idly say, in this case, that the person was prey'd upon by the innate heat, in conjunction with the vestal fire; which innate heat, and the radical moisture of the body being consumed, the man must immediately die.

Hippocrates would, indeed, presently pronounce the sentence of death upon any one sick of an unknown distemper, wherein all the secretions were obstructed; whilst the skin appear'd squalid, dry, and parched: But a chemist will go deeper into the nature of the thing; and shew you, that the aqueous and spirituous parts of the blood being here wanting, the salts, which are now render'd more sharp and corrosive, are brought, by the law of circulation, to the fine tender vessels of the *cerebrum* and *cerebellum*, which they either wound and tear, or else prevent the secretion of the animal and vital spirits therein; whence death must necessarily ensue: which is saying something that satisfies the mind, and rationally accounts for the thing.

Again, *Hippocrates* tells us, if the urine be of a very red colour, smells ill, and appears frothy, the life of the patient is in danger; but 'tis chemistry which lets us know, that oil or sulphur is the cause of colours in liquors; that this oil gives a deeper colour, the finer 'tis broke; and that the more 'tis ground, and shook together, the more corrosive it grows; which, in the present case, is the true physical cause of the effect. We may,

may, therefore, say, tho' *Hippocrates* was, for his time, and the advantage he had, very well acquainted with *semeiotics*; yet a perfect knowledge thereof cannot be gain'd without chemistry. The *semeiotic* part of medicine; likewise, informs us of the constitution of the patient. Thus he, whose urine is always red, ought to suspect a putrefaction of his juices, or a dangerous tendency thereto; as he, who always makes it pale and limpid, may be thence known to be of a weak constitution. And when the sweat, as well as the urine of a person, grows fetid, we learn from chemistry, that its salts are too much attenuated, and the oils too much exalted: nor could we, without the assistance of this art, understand why the chyle should sometimes turn acid in the stomach, or *prima via*, nor perhaps how animal digestion is perform'd.

4. *Hygiene*, which is the fourth branch of medicine, instructs us in the *Hygiene*. way of preserving health by diet: and this entirely depends upon chemistry; which alone can shew when animal, and when vegetable food is proper; to what constitutions water, and to what wine is best adapted; where bread, and where flesh is to be used; what is the diet requisite for a man of a studious, sedentary life; what for a man of an active employ; and what for a child; which habits demand the use of alkalies, and which of acids: with many other particulars of like kind. 'Tis true, all these things are discoverable by experiments, made on the persons: but danger attends the making of such experiments; whilst chemistry, without running any risque at all, shews us, that the natural heat of our bodies will turn vegetables acid, and putrefy animal substances. Whence we may learn, that in case of an alkaline disposition of the blood and juices, when the urine appears red, smells ill, and tastes alkalious; vegetable acids are the proper diet, and animal food prejudicial. On the contrary, if the humours are acid, as frequently happens in infants convulsed from a coagulation of the milk in their stomachs, broths made of the flesh of animals, eggs, or the like, are excellent; whilst vegetable acids would prove hurtful. And this can be learnt from nothing but chemistry; which also instructs us to give each kind of food its proper sauce or menstruum, to forward its concoction or dissolution in the stomach.

5. As for the *therapeutic*, or last part of physic, which regards the cure *And therapeutic* of diseases; all the genuine indications of it are fetched from chemistry *tics*, alone. When a patient is seized with a burning fever, chemistry immediately informs us, that, from the additional heat, the salts of the blood become sharper; and, as the heat increases, are render'd alkaline, and the oils more volatile, and exhalable. Whence we infer, that acids ought to be prescribed, to prevent the putrefaction that is bringing upon the juices: and this indication could be fetched from nothing but chemistry.

'Tis very remarkable of the famous Dr. Sydenham, a strict follower of *Hippocrates*, that having never read any thing of chemistry or anatomy, he was, about the sixtieth year of his age, struck with consternation at the horrid devastation made by the confluent *small-pox* in England; whilst all the

the remedies he applied, availed nothing towards abating the violence of the distemper: so that it kill'd as many as it seized on. At length, after it had dispatched thousands, the Doctor tells us he discovered, that as often as he let his patients, in this case, drink small-beer acidulated with spirit of vitriol, they constantly recover'd: hereby furnishing us with an eminent instance of the great usefulness of chemistry to a physician; which had he but understood, the lives of those he before suffer'd to die of this distemper, might have been happily saved. His ignorance of this art drove him to a like distress in the cure of convulsions in children; whom he saw die in great numbers, notwithstanding his utmost efforts to prevent it; till happening to prescribe them a few drops of spirit of hart's-horn in water, many, he thanks God, were by this means snatch'd from the jaws of death. And how could the venereal disease have been cured, had not this art taught us the use of mercury? To what purpose served all the purges, glysters, vomits, and other things of that tribe, till this was discover'd? By this *Paracelsus* raised himself a name, and *Carpus* became immensely rich. But I should never have done, were I to enumerate all the useful discoveries made in the curative part of medicine by means of chemistry; which has put numberless remedies of great virtue into our hands, that the *Galenists* were strangers to. I need not on this occasion mention Mr. *Boyle's Ens Veneris*, so serviceable in the rickets; nor the chemical oil of cinnamon, so successful in all female disorders, and particularly those of virgins. Nor is the art of chirurgery, which regards only the cure of the solids, less indebted to chemistry; as will be fully shewn under the processes in our third part: So that this art evidently appears to be highly necessary and useful in every branch of physic. But I would not have it inferr'd from hence, that the antient physicians dishonour'd their profession by their ignorance hereof; tho', doubtless, had they understood chemistry, they would have practis'd to greater advantage: and thus much themselves acknowledge in effect. *Galen* declares, that he long, in vain, endeavour'd to find out what it was in roses which had the power of cooling: Now, if he had ever distill'd them, he would have obtain'd their native spirit or quintessence, which contains all the virtues of the flower, has the faculty of cooling, and makes the rose to be what it is. *Hippocrates*, tis certain, perform'd many excellent cures without the assistance of chemistry; but then he acquired his skill by many repeated experiments, which shew'd him what was serviceable, and what prejudicial in every disease; and this could not be done without much hazard to the patient. As we are acquainted with a great variety of things unknown to the antients, the arguments drawn from their physic, without the late assistances, and particularly that of chemistry, are not to be relied on. We must own however, that physic has been a considerable sufferer by chemistry, from the licentious way of reasoning introduced into it; and the fondness of chemists in extolling every production of the furnace for a medicine: yet the faculty at *Paris* carried their resentment too high, when they would have utterly expelled it their art; for when used under due

limi-

limitation, nothing can be more conducive to the advancement of physic, than chemistry. And for fuller proof of this momentous assertion, I refer myself to the works of those two unexceptionable authors, the great Lord Bacon and the excellent Mr. Boyle; after whom there is scarce any author, in this way, deserving to be mention'd, at least, in comparison of them; their successors having done little more than repeat their experiments, or barely transcribe their works. The best physicians since their times, have been shamefully ignorant in chemistry; and the best chemists as generally unskill'd in medicine*.

* The general ignorance of the antient physicians in the chemical part of their profession, led some of their modern admirers into a firm persuasion, that chemistry was of no significance therein: as if, because neither Hippocrates, nor Galen, ever saw a distill'd water, all such waters must be a trifle. The first application of chemistry to the purposes of medicine, we have already traced out in the histories of Basil Valentine, Paracelsus, and Helmont.

In the days of Helmont, this kind of knowledge had gain'd considerable ground; and two men of eminence, Sir Theodore Mayerne, and Quercetan, profess'd it publickly at Paris; tho' they were strenuously oppos'd therein by the faculty, who commission'd one of their members to write an apology for Hippocrates and Galen, against the innovators: But these still proving obstinate, were in the year 1603, publickly censured, condemned, and ejected, together with their writings, and their art, by the consent of the whole college. This rash procedure only the more excited the chemists to write and

divulge their experiments, and made their doctrine more inquired after: upon which, the physicians of Europe divided into sects under the name of Galenists and Chemists. Many a learned pen was now drawn in defence of the antients; and many an one to recommend the new-found art. In the mean time, fresh discoveries in chemistry were daily made, and the number of its admirers increased; so that the Galenists themselves were at length prevailed upon secretly to try the effects of chemical medicines: which gave them to see, that chemistry was not, as they imagined, to be rashly condemned by the lump. And this at length ended in a friendly union of the two pharmacies, Galenical and Chemical; which must be allow'd one of the greatest and happiest accessions the art of medicine ever receiv'd. The *methodus prescribendi* entirely depends upon a knowledge of chemistry; and to the want of this are owing those gross errors so frequently committed by dispensatory-writers, in ordering the standing medicines of the shops.

Uses of Chemistry in the Mechanical Arts.

THE third use of chemistry is *mechanical*, or, in the *mechanical arts*; to distinguish it from that other branch of mechanics, the doctrine of motion; which belongs to mathematics.

Mechanics, what,

Mechanics, as here considered, is the art of changing sensible bodies, for human uses, without the exactness, and precision of geometrical rules, and demonstrations: in which sense, a work, or effect of such art, is call'd a piece of *mechanism**.

Now the prime use of chemistry is in such arts: none of which but has received great improvements, and is still in a way of receiving many more, from this noble art; which on this very account has ever been held in the highest esteem by princes, and great men, who had the interest of trades, arts, and manufactures at heart. We shall specify its uses in some of the more considerable: and,

Usefulness of chemistry in the art of painting.

1^o, In the art of painting; an art which forms figures, by the draught of lines and colours, and touches surfaces till they resemble natural bodies. Now there is nothing painting stands in so much need of, as chemistry: the great point a painter is solicitous about, is to have good colours, that is, such as shall retain their lustre, force, hue, homogeneity, and transparency; and 'tis by chemistry alone that such colours are prepared: witness *ultra marine* †, *cinnabar* ‖, *vermillion* **, *lacca* ††, &c. And particularly the first, which is a noble vivid blue, and the only durable colour of the kind; all other

* "The antients," says Sir *Is. Newton*, "made two kinds of mechanics: *rational*, which proceeds by demonstration; and *practical*, to which belong the manual arts, whence the name mechanics was originally taken. But in regard artificers usually work inaccurately, by this means mechanics have come to be distinguished from geometry; so that whatever is accurately done, is referr'd to geometry, and the rest, less accurately perform'd, to mechanics. Yet does not the difference lie in the thing, but wholly in the men. He that works accurately, is an imperfect mechanic; and he must be allowed the best of all mechanics, who works the most accurately of all. In effect, mechanics, or the mechanic arts, are, as it were, the basis of geometry; the drawing of right lines and circles, which geometry is to consider, being wholly mechanical." *Prof. ad Phil. Nat. Princ. Math.*

† *Ultra marine*. The method of preparing it, we have already given in the notes, p. 137.

‖ *Cinnabar*. See what we have already observed hereof, in the notes, p. 132.

** *Vermillion*, the antient minium, is prepared of native cinnabar, by grinding it up with spirit of wine, and urine, and then drying it.

†† *Lacca*, or *lake*, is a fine red, of three kinds, viz. *Venetian*, *dove-colour'd*, and *liquid*: the first is made of the bone of the cuttle-fish pulverized, and colour'd with a tincture of cochineel, and *Brasil* wood, boil'd in a lixivium of burnt alum, arsenic, natrum, or the salt of kali, reduced into a paste, and form'd into tablets or cakes. The second is made of shreds, floss, or sheerings of scarlet, boiled in the same lye as the former, strained, and cast upon powder'd chalk, and alum, to be form'd into tablets. The third is only a tincture of the wood call'd *Fernamboug*, drawn by acid juices. *Savary*. There

other blues, and consequently the greens depending thereon, fading, and losing all their beauty in course of time. The chemical process for making it, is somewhat long : See *Anth. Neri, de producto azyron*. Add, that it is chemistry which teaches how to mix and compound colours ; what vapours spoil and deface 'em ; and what means, as varnishes, &c. are to be used to preserve 'em.

As to the other branch of painting, viz. on glass, whereby colours are laid on that body without destroying its transparency ; tho' it be of an ancient standing, yet was almost lost, and only at length restored by means of chemistry. *Kunckel* was the first who retrieved this noble art ; who, tho' he speaks of it in terms scarce intelligible ; yet was undoubtedly well seen therein*.

A

There are also yellow lakes, orange lakes, &c. procured, in the like way of tinctures, from broom-flowers, poppies, flower-de-luces, roses, violets, mallows, &c. *Anth. Neri, de re vitrar.*

* The colours used in staining or painting on glass, are all of the metalline, or mineral kind, and not procured without chemical operations, and many of 'em painful ones too : *Black*, according to *Felibien*, is made of scales of iron, ground with glass beads : *White*, with sand, calcined, pounded, mixed with salt-petre, and the mixture recalcined, repulveriz'd, &c. *Yellow* is leaf-silver, ground, and mix'd in a crucible, with sulphur or salt-petre ; ground a second time and mix'd with oker. *Red* is made of litharge of silver, and scales of iron, gum arabic, glass-beads, blood-stone, &c. *Green*, of *as ustum*, black lead and sand calcined, and incorporated ; then salt-petre added ; then calcined a second time, and a third time yet e'er it be used. *Blue*, *purple* and *violet*, are prepared like green, only leaving out the *as ustum*, and in lieu thereof using sulphur, for sky blue ; perigueux for purple ; and both for violet. We must add, however, that these colours are not universal ; most painters on glass having their particular ones, which they keep secrets.

Method of staining or painting on glass.

To paint on glass, they first design their subject on paper ; then make choice of pieces of glass, proper to receive the several parts ; and thus proceed to distribute the design on the paper it self into pieces suitable to those of the glass : contriving,

that the glasses may join in the outlines of the figures, and the folds of the draperies ; that so the carnations, and other finer parts may not be damaged by the lead, in joining the pieces together.

The distribution made, they mark all the glasses, as well as the papers, with letters, or numbers, that they may be known again. Which done, applying each part of the design on the glass intended for it, they copy, or transfer the same upon the glass, with the black colour diluted in gum-water, by tracing and following all the lines and strokes as they appear thro' the glass, with the point of a pencil.

When the first strokes are well dried, which happens in about two days, if the work be only in black and white, they give it a slight wash over with urine, gum-arabic, and a little black ; and this several times repeated, according as the shades are desired to be heightened : with this circumstance, never to apply a new lay till the former is sufficiently dried. This done, the lights and risings are given by rubbing off the colour in those places with a wooden point, or the handle of the pencil.

As to the other colours above mentioned, they are used with gum-water, much as in painting in miniature ; taking care to apply them lightly, for fear of effacing the out-lines of the design ; or even for the greater security, to apply them on the other side : especially the yellow, which is very pernicious to the other colours, by blending therewith.

D d

And

Enamelling.

A third manner of painting, call'd *enamelling*, or the art of laying the finest colours on metals, and precious stones, stands wholly on the footing of chemistry: nor can any thing be written on the subject but what is fetch'd from that art †. See *Isaacus Hollandus on enamelling*.

2°, In

And here too, as in pieces of black and white, particular regard must be had, not to lay colour upon colour, or lay on lay, till such time as the former are well dried. It may be added, that yellow is the only colour that penetrates the glass, and incorporates therewith by the fire: the rest, and particularly the blue, which is very difficult to use, remaining on the surface, or at least entering very little.

When the painting of all the pieces is finish'd, they are carried to the furnace to anneal, or bake, and fix the colours thereon. This furnace is small, and built of brick; a little above the bottom is an aperture to put in fuel, over which is a grate, which traverses the furnace, and divides it into two parts; above this is an aperture, thro' which to take out pieces, and examine how the coction goes forward.

On the grate is a square earthen pan, on one side whereof, is a little aperture, thro' which to make the trials, placed directly opposite to that in the furnace destined for the same end.

In this pan are the pieces of glass placed in the following manner: first, the bottom is covered with three strata of plaister, or beaten lime, separated from each other, by two others, of broken glass; serving to secure the painted glass from the too intense heat of the fire. The glasses are laid horizontally on the uppermost layer of this plaister or lime.

This first row of glasses they cover with a lay of the same powder, an inch deep; and over this lay another range of glasses: and thus alternately till the pan is quite full.

The pan thus prepared, they cover up the furnace with tiles, or a square table of earth closely luted all round; only leaving five little apertures, one at each corner, and another in the middle, to serve as chimneys.

Things thus disposed, there remains nothing but to give fire to the work: the

fire for the two first hours must be very moderate, to be increased in proportion as the coction advances, for the space of ten or twelve hours, in which time it is usually compleated. At last, the fire, which at first was only of charcoal, is made of dry wood; so that the flame covers the whole pan, and even issues out at the chimneys.

During the last hours, they make essays from time to time, by taking out pieces thro' the little aperture of the furnace, to see whether the yellow be perfect, and the other colours in good order. When the annealing is thought sufficient, they proceed hastily to extinguish the fire, which otherwise would soon burn the colours, and break the glasses.

† The *enamels*, or colours used in this art, have for their basis a pure crystal glass or frit, ground up with a fine calx of lead and tin prepared for the purpose; with the addition, usually, of white salt of tartar. These ingredients baked together, are the matter of all enamels; which are made by adding colours of this, or that kind, in powder, to this matter, and melting or incorporating 'em together in a furnace: when melted, they are cast into water; and when dry, melted over again, and the colour rais'd, or taken down at discretion. For *white enamel*, *Neri* directs only manganese to be added to the matter. For *azure*, zaffer mix'd with calx of brass. For *green*, calx of brass, with scales of iron, or with *crocus martis*. For *black*, zaffer, with manganese, or with *crocus martis*; or manganese with tartar. For *red*, manganese, or calx of copper and red tartar. For *purple*, manganese with calx of brass. For *yellow*, tartar and manganese. *De Arte vitrar.*

Enamelling, to appear in perfection, should only be practised on plates of gold; the other metals being less pure: copper, for instance, scales with the application, and yields fumes; and silver turns the yellows white. Nor must the plate be made

2^o, In the art of dying, by which we mean that noble invention of tinging wools, silks, linnens, &c. with the brightest colours. For most of the best colours are owing to chemistry, particularly *blue*, i. e. indigo^{**}; and *red*, i. e. scarlet; which last was first introduced by *Kuffelaer*, a dyer of *Lions*, who married *Drebel's* daughter, from whom he had a *M.S.* of the father, about dying a flame colour, which furnished him with the first hint.

For *Drebel* finding, by chemical experiments, that cochineel with spirit of nitre *ll*, afforded such a colour; and finding withal, by further experiment, that the pure spirit of nitre corroded cloth, he temper'd it with tin. And hence arose that celebrated colour, which neither fire, nor water, nor salt can destroy.

Besides,

made flat; for in such case the enamel crackles: to avoid which, they usually forge 'em either a little round, or oval; and not too thick.

The plate being well and evenly forg'd, they usually begin the operation by laying on a couch of white enamel, on both sides, which prevents the metal from swelling or blistering: and this first lay, serves for the ground of all the other colours.

On the plate, thus enamell'd with white, they calk or trace the design to be painted; touching and finishing it up with some other colour. This done, the plate is set in a reverberatory furnace, to fix the colour; and the other colours applied in like manner in their turns. The white colour of the ground serves for the lights, and is therefore spared in all the places where such heightnings are required. *Felbien*, *Prin. de l'Architect. de la Sculpt. &c.*

^{**} *Indigo* is a fecula procured from the leaves of a shrub of the same name; frequent both in the *East* and *West Indies*; where they plant and cultivate it with great care. When ripe, i. e. when the leaves are brittle, and break by only touching, which happens in two months after the are planted, they cut 'em, tye 'em up in bundles, and lay 'em to rot in large vats of river, or spring water. In three or four days, the water boils and ferments by mere force of the plant heating it, &c. Upon this they stir it up with large poles; and then letting it stand to settle again, take out the wood, which is now void both of leaves and bark. Lastly, continuing to stir what remains at bottom divers times, after it has settled for good, they let out the water, take the sediment which remains at bottom, put it in forms, or

moulds, and expose it in the air to dry: and this is indigo. This is the most usual way of preparing it. Others practise it with some variety.

ll Authors are divided, as to the nature of cochineel; some taking it for a worm, and others for the grain or seed of a tree. *F. Plumier*, the *Minime*, maintains the former opinion, and *Pomet* the latter.

It may perhaps be said they are both in the right, and yet both in the wrong; and that there is cochineel of either kind. This at least, appears from the account given by *Dampier*; who describes each kind.

"The cochineel worm, he says, is an insect gender'd in a fruit resembling a pear: the shrub which bears it, is five or six foot high, and call'd *tonna*, of which [they have whole plantations about *Guatimala*, *Chepe*, and *Guexaca*. At top of the fruit grows a red flower, which when mature, falls on the fruit; and that opening, discovers a cleft two or three inches diameter. The fruit then appears full of little red insects, having wings of a surprizing smallness, and which would die and rot there, if not taken out. The *Indians* therefore spreading a cloth under the tree, shake it with poles, till the insects are forc'd to quit their lodging, and fly about the tree, which they cannot do many moments, but rumble down dead into the cloth; where they are left till entirely dry. When the insect flies, it is red; when fallen, it is black; and when dry, white; it afterwards changes colour.

"Cochineel grain," or, as *Dampier* calls it, *sylvestris*, "is a red berry, growing in *America*, found in a fruit resembling that of the cochineel tree, or *tonna*. The

Besides, no colours will stick to wool, or silk, unless there have first been a fermentation, which is purely chemical. If then I would dye silk, *e. gr.* scarlet, there are two things required: 1^o, a proper colour; and 2^o, that the colour stick to the silk; both of which depend on chemistry. For as to the first, if the silk be first boil'd in a lixivium, the colour readily adheres: And as to the second, that colour cannot be prepared without *Aqua fortis*, or spirit of nitre; and that again, as already observed, is to be temper'd with tin: And thus all the durable metallic colours are only to be had by this art. Nor can a dyer use 'em to their utmost advantage, without the assistance thereof.

Art of glass.

3^o, *In the art of glass*; an art, how noble, how necessary, and how advantageous to mankind! by which alone we let in light, and warmth, and keep out the air, filth, &c.

Its first rise * it had in *Egypt*, and its perfection in *England*: But both are apparently owing to chemistry.

It is made of sand calcined, or of flints often ignited, and as often suddenly extinguished in water, to render them friable, and then pulverized, and mix'd with an equal quantity of vegetable ashes, for the sake of the fix'd al-

" first shoots produce a yellow flower;
" then comes the fruit, which is long,
" and when ripe, opens with a clift of
" three or four inches. The fruit is full
" of kernels or grains, which fall, on the
" least agitation, and which the *Indians*
" take care to gather. Eight or ten of
" these fruits may yield about an ounce
" of grain.

" This berry yields a dye almost as
" beautiful as that of the insect, and a
" person may be easily deceived in them;
" tho' the first is much less esteem'd."

* *Neri* traces the antiquity of glass as far back as the time of *Job*: That writer, speaking of the value of wisdom, c. 28. v. 17. says, that gold and glass are not to be equal'd to it: so, at least, our version has it, after the *Septuagint*, *Vulgate*, the *Syriac*, *St. Jerom*, &c. But in other translations, as well as in the original *Hebrew*, the word glass is not seen: instead thereof, the *Chaldee* uses crystal; the *Arabic*, jacinth; the *Italian*, *Spanish*, *French*, *Dutch*, a diamond; the *Targum*, a looking-glass; *Pagninus*, a precious stone; *Vatable*, a berry, &c. The reason of all this diversity arises hence, that the original word *Zechuckich* comes from the root *Zacac*, which signifies to purify, cleanse, shine, be white, or transparent; whence the same word is applied to frankincense, *Exod.* 30. 34.

where the *Septuagint* renders it pellucid: so that the word may equally signify any thing beautiful, and transparent; and is by no means peculiarly appropriated to express what we now call glass. *Merret. Observ. in Anth. Neri.*

Pliny relates, that " glass was first discovered by accident in *Syria*, at the mouth of the river *Belus*, by certain merchants driven thither by the fortune of the sea, and obliged to continue there, and dress their victuals by making a fire on the ground; where there being great store of the herb *kali*, that plant burning to ashes, its salts mixed and incorporated with sand or stones fit to vitrify or make glass." *Hist. Nat. lib.* 36.

Dr. Merret will have glass as antient as either pottery, or making bricks; for that a kiln of bricks can scarce be burnt, or a batch of pottery be made, but some of the bricks, and the ware, will be at least superficially turn'd to glass: so that it must have been known at the building of *Babel*, and as long before as that art was used; and likewise by the *Egyptians*, among whom the *Israelites* were many years employ'd in making bricks. *Observ. in Anth. Neri.* Of this kind, no doubt, was that fossil glass mentioned by *Ferrant. Imperat.* to be found under ground in places where great fires had been. *Lib.* 25. c. 7.

caline

caline salt therein: the whole they heat, and boil, till it becomes glass*.

If the sand or stone be in too great quantity, or be not beat small enough, the glass is greenish; but the more salt, and the finer the calx, the more clear and beautiful the glass.

In effect, glass is only an alkali salt, united with a calx or earth; and the more fixed the salt, and the purer the earth, the finer the glass: but then the more salt, and the finer the glass, the less it endures the air; as being subject to veins and cracks, and being easily prey'd on, and dissolved by the water in the air.

And the more the earth, the greener and more opaque the glass; but withal the more durable. Add, that the finer the glass, the more it changes bodies put therein.

4°, *In the art of gems*, by which we mean the art of making precious stones or gems, of crystal or glass, to vye in beauty, colour, hardness, &c. with natural ones.

To the perfection of this art, two things are required: First, the giving the glass or crystal an exceeding hardness, solidity, and transparency. And, 2°, the giving them a bright and transparent colour or water.

Now, the two sorts of matter just mentioned, *crystal* and *glass*, have each their particular advantages, and defects; by which they are distinguished, and indisposed to come up to the quality of gems: *Crystal*, for instance, has a noble hardness, compactness, and pellucidity; but then it does not take colour: at least the art of tinging or staining it, is not known. The chemists of the last age, 'tis true, seem to have understood it better: *Kunckel* particularly had a method of dying crystal of a beautiful red, by means of a little gold; but the secret perish'd with him †.

Mr. *Boyle*, in his excellent treatise of gems, has endeavour'd to retrieve this art, and to shew how a crystal matter may be converted into a real gem; but he never brought the thing to bear himself. All his crystals crack'd, and flaw'd; which flaws, &c. the air entering, corrupted and dissolved them: so that in a little time they lost all their transparency.

As to *glass*, it receives any colour, and that in all imaginable perfection; but then it wants both of weight, compactness, and hardness; witness its being cut by a crystal, as by a diamond: But, which is more, it is defective too in the point of smoothness, and polish: for if its surface be a little rubbed, or ground, it appears rough and unequal, and loses all its transparency and beauty; whereas rock-crystal takes the noblest polish. However, in point of colour, glass excels every thing.

* The nature and ingredients of glass, with the process of making it, &c. we have already described in the notes, p. 139, 140.

† Tho' crystal, in not being fusible, becomes unsusceptible of dyes, or tinctures in substance; yet the industry of the chemists has found means of making it serve for the basis of precious stones, with all the advantages of colour. Tho' we cannot fuse, we can calcine, and make frit of it.

To make, e. gr. a fine, vivid, durable blue; take pure salt, and sea-sand: boil these a long time in an intense fire, then mix a tincture of copper; and continue the heat till all three be fused, and vitrified: the result will be a gem, or emerald, nothing inferior in beauty to a native one; and such, as we have known the most experienced lapidaries deceived in. We

¶ The art of imitating precious stones in glass, is too curious and considerable to be pass'd over without further notice; some of the leading compositions therein, we shall briefly point out, on the authority of the never-enough to be commended *Neri*.

To make a sea-green glass; Take crystal frit, without allowing it any manganese; melt it, and when clear, a salt will be found swimming a-top, in form of an oil, which is to be skim'd off, as long as any rises. When the glass is perfectly clarified, mix calcined brass, and zaffer; and add the mixture to the melted crystal. Let the whole stand three hours, that the colour may incorporate with the metal: then stir and mix them again; take a proof, and either heighten or take down the colour.—

For an emerald-colour glass, use crystalline metal that has had no manganese, pass it thro' water once or twice, to get out all the salt; add half the quantity of common white metal made of pulverine; and when the mixture is well purified, add brass thrice calcined, and *crocus martis* calcined with brimstone, and reverberated: If any blueness remain, add more of the *crocus*.—For a turcois-colour glass, evaporate all the moisture from a sea-salt, till it become white; then pulverize it: this powder add, by degrees, to a sea-green crystal metal, mentioned above, mixing it well together, till the sea-green lose its transparency, and become opaque, which is the effect of the salt, now vitrified. Upon this, a little paleness arises, and by degrees the sky-blue, which is the colour of a turcois-stone.—To make calcidony, jaspers, and agats, in glass; dissolve silver in *Aqua fortis*, and also mercury in *Aqua fortis*; mix the solutions in a glass body, and to the mixture add sal-ammoniac; when dissolved, add zaffer, manganese, ferretto, *crocus martis*, thrice calcined copper, blue smalt, and red lead, all in powder; keep the body stopp'd ten days, stirring it daily: then put it in a sand-fur-

nace; in twenty-four hours the *Aqua fortis* will be evaporated, leaving a powder at bottom. Lastly, take very clear metal, made of broken pieces of crystal, and crystalline vessels, and white glass that has been used: to twenty pound of this, add two ounces and a half of the powder; mix, and incorporate them, and let them stand in the fire twenty-four hours; upon this, when grown cold, waves and clouds of beautiful colours will begin to appear. Add, tartar, vitrified soot, and *crocus martis*, calcined with brimstone, all powder'd and mix'd, to the composition: let it boil, and settle twenty-four hours; and then make a glass body of it, which put in the furnace again and again, till there appear fine streaks, and shades of blue, red, sea-green, yellow, and all other colours; in which state it is ready to be wrought into variegated vessels, &c.

To make a gold-yellow in glass, mix crystal frit with common glass frit, and to the mixture add tartar beaten and searced, and manganese; place them in a furnace four days, with an ordinary fire; when sufficiently purified, and colour'd, work it.—For a granat colour, to crystal, and common frit mix'd, add manganese, and zaffer; put them in a pot, and keep them in the furnace twenty-four hours.—For an amethyst colour, to crystal frit add manganese and zaffer, as before.—For a saphyr colour, either to common or crystal frit, add zaffer and manganese; mix and melt them in the furnace, and, when well-colour'd, work it.—For a black colour, to crystal and common frit, add calc of lead and tin; mix, and set them in the furnace: when the metal is melted, and pure, add powder of calcined steel, scales of iron; after boiling with the mixture, let them stand and settle twelve hours.—For a snow-white, to crystal frit add calcined tin, and manganese; mix them, and set them in the furnace to refine, for eighteen hours: then cast the matter into water, and make a proof: if it be too clear, add more of the tin.—For a marble colour,

We have lately seen an eminent artist at *Amsterdam*, the same who first set on foot the method of making *porcelain* of glass; and were shewn by him glasses of all imaginable colours*. He has the art of imitating to the life any human eye †, and all upon a single piece of convex glass; not by painting it, but only applying glass to glass. He assured us, he learnt all his art from *de Neri*, and *Kunckel* in his comments on the same; which last author made a sort of precious glasses in the court of *Prussia*, equal to any precious stones; some of a ruby colour, with gold; others of a smaragd colour, with copper, &c. See *Joh. Kunckelii Vollkommene Glasmacherkunst*, d. 1. *Ant. Neri* 7. *Bucher de Arte Vittraria*.

colour, crystal frit melted, and work'd without purifying, suffices.—For a deep red, put crystal frit, broken white glass, and calcined tin, in a pot to melt, and purify; and when in fusion, add calcined steel, and scales of iron, well powder'd, thereto; mix, and let them incorporate five or six hours. Make an essay, and if the metal be too black or opaque, add brass calcined to a redness; mix, refine, and make essay as before, till it be of a blood-red; and work it speedily, lest it lose its colour.

* It is no inconsiderable improvement of the art of imitating gems in glass, to make use of glass of lead; the stones produced hereby, far exceeding those made of common glass, or even of crystal, in point of colour. To prepare this glass, the lead is first fused and calcined in a kiln; then re-calcined by a reverberatory fire; and lastly, pulverine or rochetta frit being mixed therewith, and the whole set in the furnace for ten hours, it is cast out into water, and the glass separated from the lead.

This glass may be blown or work'd into vessels, after the usual manner.—It becomes of an emerald colour, by the addition of pulverine frit to purify it, and brass thrice calcined, and *crocus martis* made with vinegar, incorporated therewith.—A topaz-colour, by using crystal frit instead of pulverine frit, and adding half the quantity of yellow glass.—A granate colour, by adding crystal frit, manganese, and saffer.—A gold-colour, by adding crystal frit, brass thrice calcined, and *crocus martis*.—Colour of lapis lazuli, by adding the snow-white glass above-mentioned, with the painters blue smalt. *Neri ubi supra*.

† M. Homberg gives us a new and curious application of the art of glass to the copying of engraven stones, and taking figures or impressions thereof, equally beautiful with the originals. He even assures us, that he made copies this way from a great number of such stones, furnished him by the Dutchess of Orleans, in such perfection, that some of the most experienced persons took them for antique.

“The whole method consists in moulding the graven stone in a fine earth, and imprinting therein a piece of glass half melted by the fire, in such manner, as that the figure of the stone remains accurately impressed on the glass.”

The chief difficulty lies in finding an earth fine enough to take the figure, and yet that shall not melt, mix, stick to, and incorporate with the melted glass, which itself is little else but a sort of earth. The character of such earth must be, that it have as little salt as possible, salt disposing more easily to fusion. Of all the earths whereof M. Homberg made trial, the least saline, and that which he found fittest for the purpose, was a sort of chalk, called *tripoli* of Venice, commonly used in polishing looking glasses, optic-glasses, and precious stones: Tho' there is also a coarser *tripoli* found in France, of some stead, in saving the too great expence of the former.

The process is thus; pounding the French *tripoli*, pass it thro' a hair sieve, scrape the *tripoli* of Venice very fine with a knife or piece of glass; pass it thro' a fine silk sieve, and pound it in a glass mortar, with a pestle of glass.

Proceed now to moisten the French *tripoli* with water, till it may be made into

Art of fossils.

5°, *In the art of fossils*; it being chemistry alone that shews to find the metalline glebe or ore in the mines; to judge of the value, and richness of earths; to discover whether or no there be any metal in them, and what metal it is; as also how they are to be dug, and the metal procured, and separated from all heterogeneous matters; and lastly, how it is to be cleared of other metals mix'd therewith.

'Tis certain, the *Spaniards* have lost many millions in *America*, for want of the method of separating gold from other matters, by mercury; for gold is there rarely found without being mix'd with other bodies, and this so strongly, as not to be separable by *Aqua fortis*, nor by any other means; till a chemist, invited over into *Peru* on that occasion, first applied mercury, which, uniting the gold to itself, left the rest behind*.

We are told of another, who had the art of separating all the sulphur from tin; which left the metal as fine as silver: but that secret perished with him.

Art of metals.

6°, *In the art of metals*, by which we mean the art of refining metals, and rendering them malleable, and fit to be wrought into utensils, and other occasions of life.

Now the malleability of metals, as already noted, depends on their being free of sulphur: Thus, a little arsenic, or other sulphurous matter, being added to gold, it immediately commences friable, and easily crumbles into a fine powder. To purge out all the sulphurous part, therefore, without carrying any of the metalline part along with it; it must be known what bodies attract, and draw the sulphur to them, leaving the metal behind; which is a thing chemistry alone can teach, and by which the *Spaniards* save immense riches in their *American* works, which would otherwise be lost. All the secret

a paste by squeezing it between the fingers; and therewith fill a little flat crucible, pressing it lightly into the same: then strew some dry powder of the *Venice tripoli* over it; and on this lay the stone intended to be moulded; pressing it strongly into the same with the fingers, and flattening down the *tripoli* all around it. Here letting it remain a while, for the moisture of the *French tripoli* to penetrate the *Venetian*; turn the crucible upside down; upon which the stone falls out, leaving its impression behind.

The crucible having now stood till perfectly dry, take a piece of glass of any colour at pleasure, and of a size answerable to the work intended, and expose it in a furnace till it begin to shine, which shews it sufficiently softened for the impression. Upon this, immediately apply it with a piece of iron into the

the cavity of the mould; and as soon as it has taken the impression, set the crucible in a warm place in a furnace, that the glass may cool by degrees, without cracking: when cold, it is taken out of the crucible, compleat.

To copy a stone *in Creux*, that is, imboss'd, or wrought *in Relievo*; or to copy *in Relievo* a stone wrought *in Creux*, proceed thus:

Take the impression of the stone in *Spanish* wax, or sulphur, and pare off all that is superfluous on the edges; mould this waxen impression, in a crucible of *tripoli*, in the same manner as if it were a stone; and take an impression thereof in a piece of glass, as above taught. *Mem. de l'Acad. An. 1716.*

* See what has been already deliver'd hereof, in p. 70 & 74.

consists in casting in an alcali salt, which absorbs the sulphur, and leaves the metal untouched.

'Tis chemistry, which alone teaches how to temper metals, and make them ductile, or rigid, or hard, or tender, &c. Thus pure gold is scarce of any real use in life, as being so exceedingly soft, and perishable; but fuse it with a little copper, and the colour rises more beautiful, and the metal more firm and durable. The same may be said of pure silver, which is too soft for use; but mix a little tin with it, and it becomes more ductile, and durable.

7°. In the art of war, which, as now managed, owes all its force to Military art: gun-powder; immediately upon the discovery of which, guns, mortars, bombs, and other furniture of war, were introduced.

In reality, 'tis this powder is the very basis of the modern military art; that, by which sieges, and defences of towns, battles, &c. are performed. And hence it was, that Coehorn, by being thoroughly acquainted with the force of gun-powder, bore the palm from all the world, in this way.

Now, gun-powder is a mere chemical production; and, as such, is Gun-powder usually ascribed to * Bartholdus Schwartz, a German monk; tho', in reality,

its

* What evidently shews the ordinary account of its invention false, is, that Schwartz is held to have first taught it the Venetians in the year 1380; and that they first used it in the war against the Genoeze in a place antiently call'd Fossa Caudeana, now Chioggia. For we find mention of fire-arms much earlier: Peter Messius, in his *Varia Lestiones*, relates, that Alphonsus XI. King of Castile, used mortars against the Moors, in a siege in 1348; and Don Pedro, bishop of Leon, in his chronicle, mentions the same to have been used above four hundred years ago, by the people of Tunis, in a sea-fight against the Moorish king of Sevil. Du Cange adds, that there is mention made of this powder in the registers of the chambers of accounts in France, as early as the year 1338.

The composition of gun-powder is as follows: Take six pound of salt-petre well purified, and reduced to powder; one of sulphur, likewise, purified, and powder'd; and at least one of charcoal: put these ingredients in a mortar, moisten them with water, spirit of wine, vinegar, or urine, and pound them for twenty-four hours, remembering to moisten from time to time, to prevent the mass from taking fire. This done, squeeze it thro' a sieve. By this means it will be form'd into little grains or globules, which being

dried, are the gun-powder. *Wolffs Element. Pyrotech.*

Other authors prescribe other proportions: Semienowitz, for mortars directs 100 pounds of salt-petre, 25 of sulphur, and as many of charcoal; for great guns, 100 pounds of salt-petre, 15 of sulphur, and 18 of salt-petre; for muskets and pistols, 100 pound of salt-petre, 8 of sulphur, and 10 of charcoal. *Pyrotech.*

Miethius extols the proportion of one pound of salt-petre to three ounces of charcoal, and two, or two and a quarter of sulphur; than which, he affirms, no gun-powder can possibly be stronger. He adds, that the usual practice of making the gun-powder weaker for mortars, than guns, as in the example above, is without any foundation, and renders the expence needlessly much greater: for, whereas to load a large mortar, 24 pound of common powder is required; and, consequently, to load it ten times, 240 pound: he shews, by calculation, that the same effect would be had by 180 pound of the strong powder. *Artiller. Prax. Recent.*

The explosion of gun-powder is thus accounted for by Sir Isaac Newton: "The charcoal and sulphur easily taking fire, kindle the nitre, and the spirit of the nitre being thereby rarefied into vapour, rushes out with vehemence, much after the same manner

E c

" as

its first discoverer appears to have been Friar Bacon, who 'tis certain was master of the secret; but out of good will to mankind concealed it*.

The same powder, we can make by chemistry much more powerful; viz. by adding salt of tartar to the salt-petre, sulphur and charcoal †.

Granadoes.

Misive fires or *granadoes* are likewise capable of being made to burn, and have their effect invisibly, or under water, &c. Add, that if *Aqua fortis*, or oil of vitriol, be mix'd with the composition of a hand granado, every living thing near the place of explosion will be suffocated.

Inextinguishable fire.

Indeed, 'tis to be lamented, an art so fatal and pernicious to mankind, should ever have arose from chemistry: but, what shall we say? the same chemistry would furnish divers others vastly worse and more forcible. Perhaps, it were better to be silent about them: but this we may affirm, that we have seen, and made, such experiments, as to the burning and dilating of bodies, as have struck us with horror and amazement. One we cannot omit, as being already known to several: Take, *e. gr.* an ounce of oil of caraways, and an ounce of strong spirit of nitre, each in a separate phial; the minute they come to be mix'd together, by the collision or breaking of the two glasses, such a fume and flame will arise, as will catch and consume whatever is in its way, without any possibility of its being extinguish'd*†. For it will have its full effect in water, and even *in vacuo* ‖. Hannibal antiently overcame a powerful enemy, in a sea-engagement, by pots full of snakes thrown on their vessels, which breaking upon the same,

"as the vapour of water out of an azole pile; the sulphur also being volatile is converted into vapour, and augments the explosion; and the acid vapour of the sulphur, viz. that which distils under a bell, into oil of sulphur, entering violently into the fixt body of the nitre, lets loose the spirit of the nitre, and excites a greater fermentation, whereby the heat is further augmented, and the fix'd body of the nitre also rarified into fume, and the explosion thereby made more vehement and quick. *Opticks*, p. 317.

* See further in Bacon's *History*, p. 17.

† "If salt of tartar be mix'd with gunpowder, and that mixture be warm'd till it takes fire; the explosion will be more vehement and quick than of gunpowder alone: which can proceed from no other cause but the action of the vapour of the gunpowder upon the salt of tartar, whereby that salt is rarified." *Newt. Opt.* p. 317.

This makes what they call *pulvis fulminans*, whose effect Sir *Is. Newton* in the same work accounts for from the great at-

tractive force, whereby the acid spirits of the sulphur and nitre rushing towards one another, and towards the salt of tartar, by the violence of the shock turn the whole into vapour and flame. *Ibid.* p. 352, 353.

*† On this occasion we cannot omit to admire an instance of a noble and generous principle, in the late king of France, Louis XIV. A Roman chemist, S. Poli, having discovered something of this kind, of prodigious effect, came to France in 1702, on purpose to make an offer of it to that prince; who, tho' he was then going to be engag'd in a war against a powerful confederacy; yet voluntarily renounced all the advantages of such a secret; handsomely rewarded the inventor, but enjoined him to let it perish. *Hist. de l'Acad. R. des Sciences*, An. 1714.

‖ A drachm of compound spirit of nitre being poured on half a drachm of oil of caraway seeds *in vacuo*; the mixture immediately made a flash like gunpowder, and burst the exhausted receiver, which was a glass six inches wide, and eight inches deep. *Newt. Opt.*

infected

infected the men with their poison : But what might be done with a mixture of two such bodies, as would burn every thing they came near inextinguishably ?

7°, *Pyrotechny*, or the *art of fire-works*, in which the *Chinese* are so excellent ; (whereby, fires either fix'd, or missive, are contrived to exhibit all kinds of figures ;) owes its rise and all its increase to chemistry ; as 'tis this art alone that furnishes camphor, nitre, sulphur and gunpowder, which are the chief ingredients in such compositions. See more on this subject in a fine little *French* treatise call'd, *l'Art de Feu* *.

8°, In the *art of magic*, the most elegant, and surprizing of all arts ; *Magic*, whereby the public wonder and applause are so easily procured.

Now *magic* among the ancient *Chaldeans*, *Babylonians*, and *Persians*, where it was principally cultivated, signified no more than *wisdom* : and hence the *Sophi* of the *Greeks*, were by them call'd *Magi*, who being acquainted with many of the hidden powers of nature, directed 'em in such manner as to produce effects, whose causes being unknown to the vulgar, were attributed to dæmons **. And hence the art came into an undeserv'd disrepute, and the magicians became censur'd as working by compact with the devil. But this is invidious : for in the evangelist *Matthew*, the magi are said to have come from the *East* to worship *Jesus Christ* ; which no body imagines to be understood of forcerers. Hence *Roger Bacon* in his elegant treatise, *de nullitate magia*, undertakes a vindication of the term *magia*. See *Cardan de subtilitate rerum*, *Fernelius de abditis rerum causis*, *I. Baptist Porta's Magia Naturalis*.

By this art, improved and perfected by chemistry, stupendous effects may be produced ; and such as shall readily impose on the rest of the world, and pass for real miracles. Suppose, *e. gr.* the use of gunpowder unknown, except to a single person ; and this person suppose to dig a hole deep in the ground, and therein bestow a good quantity thereof, with a pistol fitted to a clock ; so, as he could exactly know the time when the explosion would be made. This done, if he should warn the people, that on such a day, and at such an hour, there would be a great earthquake, and fire burst out at such a place : would not he be deem'd a conjurer ? And if any body should go at this day to *America*, pretending to be sent from God, and offer such a miracle in confirmation of the truth of his mission ; would not every body believe in him ?

Again, if any one should foretel an earthquake to happen at such an hour, even among us ; he would be thought to deal with the devil. And yet this is easily done ; by only taking twenty pounds of iron filings, and as many of sulphur, mixing and working 'em together, and tempering 'em with a little water, so as to form a mass, half moist and half dry. This being buried three or four feet under ground, in $\frac{1}{2}$ or $\frac{1}{4}$ an hour's time, will have a prodigious effect : the earth will begin to tremble, crack and smoke ;

* Or in *Wolffius's Element. Pyrotech.*

** See more in the account of *Bacon*,
p. 16, 17.

and fire and flames will burst thro'. Such is the effect even of two cold bodies, in the cold ground *†.

Phosphorus.

Chemistry, likewise, directs us to make *phosphorus* *; a little whereof being mix'd in oil of almonds, or turpentine, and the face, hands, &c. wash'd therewith; they will be seen in a dark place, to be all in a bright flame, not inferior to fire it self: yet upon bringing the candle, or coming to the light of the sun, the face, &c. will appear in all respects like those of another.

We read in sacred writings, that *Moses's* face shone when he came out of the mount: but then it shone in the light as well as in the dark.

Suppose the magic lanthorn only known to one person; and he, while another is asleep, having made a hole in the wall of the room, applies the lanthorn thereto; so, as that the light, and one of the figures is projected on the opposite wall: the sleeper now awaking, sees a grotesque gigantic woman walking on the wall, having her head incompass'd with rays, as angels are usually represented: will not he conclude he has seen a vision? and especially if some priest had foretold it? By such a stratagem was one of the first princes of *Europe* taken, not many years ago; who having no children, and being yet unwilling to make his will in favour of his nearest relation; awaking one night, saw his mother's image represented in the brightest colours on the chamber wall; so as he readily concluded his mother herself present: by which he was persuaded to make his will, and to put an end to several bloody wars he was then engag'd in, on that very occasion.

Lightning.

By chemistry we are likewise furnish'd with a means of making an artificial flash of lightning in a room: for if a little spirit of wine be evaporated by a gentle fire out of a flat vessel, the same will be dispersed throughout the whole room: then, if any person in the night-time enter the place with a lighted candle; the spirit catching fire, the room will immediately appear all in flames, as from a sudden flash of lightning. Chemistry has likewise the art of raising a loud crack with a vehement flame, by the mere mixture of two cold liquors, *viz.* spirit of nitre, and oil of cinnamon, or oil of cloves; a quantity of which being mix'd in a glass phial, the vessel is immediately burst into a million of pieces, the room fill'd with flame and noise, and the persons present all instantly struck dead †.

*† This Sir *Is. Newton* solves on the principle of attraction, which occasions that "even the gross body of sulphur powder'd, and with an equal weight of iron filings, and a little water, made into paste, acts upon the iron, and in five or six hours, grows too hot to be touch'd, and emits a flame. *Opt. p. 354.*

* See more of this in the chapter of fire.

† "Oil of vitriol being drawn off from its weight of nitre, and from both the ingredients a compound spirit of nitre distill'd; and two parts of this spirit

"poured on one part of oil of cloves, or caraway seeds, or of any ponderous oil of vegetable or animal substances, or oil of turpentine thicken'd with a little balsam of sulphur; the liquors grow so very hot in mixing, as presently to send up a vehemently burning flame: Does not this great and sudden heat argue that the two liquors mix with violence, and that their parts in mixing run towards one another, with an accelerated motion, and clash with the greatest force? *Newton, ubi supra.*

We have a glass so prepared, as that upon the smallest stroke, nay a slight touch of the finger, it emits flame: now if a statue were cast thereof, and placed in a church, it would shew a world of miracles. *E. gr.* if a man begging of the priest a remission of sins, were ordered to go to church, and make his prayers and vows before such a statue; after which, in case he were pardoned, upon touching a finger of the statue, fire should break out as from heaven: would not this be a miracle worth the registering?

From the whole it appears, what surprizing effects a person skill'd in chemistry, and knowing how to use the powers of nature, may produce.

9^o, *In the culinary art*, which is chiefly conversant in the preparation of meats, *viz.* the seasoning, pickling, &c. to prevent 'em from putrifying, growing musty, breeding maggots, &c. *Cookery.*

Here, too, chemistry shews it self: we shall only instance one thing; *viz.* spirit of salt, which is of so vast importance to sea-faring people, when thro' scarcity of provisions, they are oblig'd to eat musty, putrified, or infected meats, that it prevents all diseases which would accrue therefrom. For, only washing such meat in spirit of sea-salt, and the spirit insinuates it self with in the pores of the flesh, purges off the rottenness, or the muria, and prevents the scurvy. *Usefulness of spirit of sea-salt.*

Job. Rudolph. Glauber shews how every body may carry about with 'em, in a phial, what will render all their corrupted esculents, and potulents, eatable, and drinkable; even corrupt water, &c. ||. He assures us, that this same spirit is the most powerful and universal corrective in all medicine; and instances of what infinite use it might be in towns besieged, where the people living mostly on putrified meats, and being unable to bear 'em, soon die. Whereas were they to wash, and elixate their meats, with a due quantity of spirit of sea-salt, the putrid fætor would be eliminated, their ill qualities corrected, and they rendered wholesome food.

10^o, *The art of making wines* of all kinds, is wholly owing to chemistry, which first shew'd the use of fermentation, and directed the raising, abating, promoting or extinguishing thereof. *Making wines.*

By *wines* we mean the juices or liquors of vegetables rais'd by fermentation to a vinous quality; *i. e.* a quality whereby when expos'd to the fire in a chemical vessel, a spirit immediately arises from the same, which is inflammable and miscible with water, and denominated *spirit of wine* †.

Now such wine may be obtained from any vegetable, and in such spirit resides all the calefactive or warming power of the vegetable. Thus the vine, the apple, the pear, plum, cherry, and other cold plants and fruits, by fermenting, yield warming wines; and thus *England*, a country not the best dispos'd for the ripening of grapes, prepares it self wines from bar- *Wine and spirit yielded by all plants.*

|| Hitherto may be referr'd the methods of judging of the salubrity of water, and of making salt-water fresh, and potable, &c. delivered hereafter in the chapter of water.

† This will be considered at large in the history of fermentation.

The same spirit
of wine procurable
from all
plants.

ley, and other corn-fruits, which yield excellent vinous spirits, in no respect different from those of distill'd *French* or *Spanish* wines.

The truth is, there scarce appears any difference in this respect, whatever vegetable you make use of: the same spirit is yielded by all, without excepting even grass. All the choice rests here, that some yield a deal more spirit than others. Now the drawing, fermenting, fining, &c. belong all to chemistry.

119. In the art of brewing, or preparing malt liquors, which is an art a thousand years old; and its invention ascribed by *Herodotus* to *Isis*, who upon wandering over divers parts of the earth, taught people the art of preparing malt liquors. *Tacitus*, also, in his book *de moribus Germanorum* *, as-

* *Mattbiolus* takes the *zythum*, and *curmi*, to be the same with the beer or ale drank in *England*, *Germany*, &c. and that the only difference between the *zythum* and *curmi* lay in the manner of the preparation, which render'd 'em either weaker or stronger. In a famous dispute at *Paris*, in the year 1668, on the subject of the bakers using the yeast of ale and beer to leaven their dough, *Mess. Patin*, *Brayer*, *Blondel*, and *Courtois*, speak of that liquor in the following terms: "Beer, says *Corn. Tacitus*, that unhappy beverage, made of "hops, and wheat or barley, corrupted "with damaged water, was no sooner discovered than it was condemned by *Dioscorides*, *Galen*, and other of the greatest physicians. They all charg'd it with prejudicing the head, nerves, and membranous parts, of vitiating the animal juices, and "of causing a more obstinate and painful "drunkenness than wine." Other physicians vindicated it, particularly *Mess. Perrault*, and *Rainssant*; who, among other things, insisted that "the hop was not a noxious herb, but, on the contrary, had apparently the faculty of cleansing the blood, and "removing obstructions; and that it was "added to the modern beers to correct the "ill qualities charged on the beer of the "antients, which differed from ours in that "it was made without hops."

In order for brewing, the barley is first to be made into malt; which is done by putting it into a cistern full of water wherein it may swim, for a longer or less time, as the weather is more or less cold; two days and nights sufficing in hot weather, and five or six in extremely cold: when sufficiently steep'd, the water is drain'd off, for twelve or twenty hours; then, being taken out, it is couch'd or

heap'd up into one or two heaps, and turn'd every five or six hours, the outermost part inwards, and the bottom upwards. As it comes or sprouts, it is spread thinner to cool, and prevent its coming too fast: when come, it is spread very thin, and turn'd twelve or twenty times a day, till the sprout is dead: then it is again thickened on the floor, and turn'd as before; great care being taken that it neither mould nor become *acrospired*, that is, that the blade don't grow out at the end opposite to the root, or the malt come and sprout at both ends. The preparation is finished with drying it on the kiln, by spreading it on a hair-cloth, or a tin bottom full of holes, over a brisk turf, or charcoal fire; stirring and turning it from time to time.

Now to proceed to the operation of brewing it self, they boil a quantity of water, and pouring enough of it upon the malt, in a mashing tub, to wet the malt as stiff as it can be well rowed about; after standing a quarter of an hour, another portion of water is added, and the rowing repeated: lastly, the full quantity of water is added, according to the intended strength of the beer or ale. The whole having stood two or three hours, is drawn off into a receiver, and fresh water thrown on for a second wort; which is to be cooler, and to stand less time than the former. The two worts being mix'd, and the hops added, the whole is put into a copper well covered, and clos'd, there to boil an hour or two. Which done, the liquor is let into a receiver, and the hops strained therefrom: when cold, the barm is added, and after fermenting or working, it remains to be tun'd up.

fures

tures us, that those people used, of antient time, to extract wine from purified corn: but there is no brewing without fermentation; and 'tis chemistry directs the manner of fermentation. *Isis*, therefore, in this light, appears to be the first chemist.

But there is no end of the mechanical uses of chemistry: all we here do, is to pick a few instances out of an infinity: half the things in common life are the effects of this art; and the same art is an endless spring of infinite others. Would the chemists apply themselves each to his several art; there is no doubt but they would readily outstrip all other artists, and bring their respective arts to the last perfection.

Uses of Chemistry in Alchemy.

THE fourth use of chemistry is in alchemy. Now alchemy is an art, *Divers means of making gold.* which teaches means unknown to common chemists, whereby to make gold: these means are, 1^o, By *separating* and bringing forth the latent gold. 2^o, By *ripening*, and perfecting the crude, indigested gold. 3^o, By *transmuting*, or changing other metals entirely into gold.

The first, is that wherein the most visible success has been met withal. *By separation.* 'Tis now past all controversy, that all metals whatever contain gold: there is scarce any silver, any lead, any copper, any iron, &c. but gold is found in it*, only 'tis usually in so small quantity, that it does not prove worth while to get it out.

The second, by *maturation*, has likewise been prosecuted to good purpose: *By maturations* we know what the matter or basis of all metals is, *viz.* mercury; and this mercury beginning to purge it self of its sulphur, first assumes the metallic nature. As it purges further and further, it inspissates and hardens more and more; till having past thro' all the stages of the less perfect metals, it becomes gold ||.

Some *Adepti* add, that gold is not so created; but grows from a seed; after the same manner as a tree is not said to be created, but is produced from a seed, and increases by degrees to such a bulk. As plants, then, have their seed whereby they are propagated; so has gold its seed, which, where it meets with a proper pabulum, grows and thrives: and again, as the first juice of a plant is crude and imperfect, so is gold in its first origin.

Now we don't see why this art should be absolutely pronounced false: one instance may let you a little into its merits: take an ounce of pure silver, and dissolve it in *Aqua fortis*, and you will get a grain of pure gold out of the same. Fuse the silver by fire, evaporate the *Aqua fortis*, and dissolve the silver a second time in *Aqua fortis*, and you will have another grain of gold. This you may repeat as often as you please, and every time you will get a fresh grain of gold: which shews that the fire produces or ripens gold out of silver.

The third branch of alchemy teaches how to make gold of other metals; which all the world cries out is impossible; tho' we don't see why: 'tis certain, that the matter of all metals is the same, *viz.* mercury, which *Transmutation.*

* See p. 81, 86, in the notes.

|| See further in p. 101, 102.

Philosopher's
stone.

Its characters.

Effects.

The same with
the fixing sul-
phur.

may be procured equally heavy from all metals. If then a body could be found, which would consume all the heterogeneous part of metals; and leave the pure mercury fixed alone; we should readily make gold. But the philosophers stone is said both to render the foreign heterogeneous parts volatile, and to fix mercury; so that the transmutation of metals does not appear impossible.

The alchemists, therefore, search for the philosophers stone, which they describe as a ponderous substance, of a ruby colour, as friable as glass, and as fusible in the fire as wax, and yet more fixed therein than gold: now a little of this, say they, thrown or poured on the baser metals, when in fusion, presently penetrates the metallic matter, makes the fæces or impurities retire therefrom; and these it burns and renders volatile, so that they fly off; and the rest of the mass is immediately turn'd, or transmuted into gold. This stone, in reality, appears to be no other than the fixing sulphur, or *sulphur metallorum*, i. e. that part in gold which fixes and coagulates the mercury into pure metal, that part we mean, vivified or render'd vital, and increased, and exalted*.

Helmont asserts, that he was master of this secret; thus: "I have seen the philosopher's stone; which a person of no longer than a night's acquaintance put into my hands; and which I myself have seen convert a whole mass of lead into gold: and I could quote a croud of persons, kings, princes, knights, &c. who will attest that they have seen the same transmutation."† Now these, whom *Helmont* quotes as evidences of the transmutation, we will allow might be imposed on; but he himself, a knowing, and sagacious chemist as he was, could scarce be so deceived: so that he must either be doom'd a liar, or we must allow the transmutation.

Requisites to the
making of gold.

This we can affirm from our own experiments, that the purest mercury found among us, has something in it that is not mercury; which taken away, the rest approaches nearly to the weight of gold: 'tis certain, a long and tedious operation is necessary to purge mercury entirely; but the further you go, still the more subtle, and purer, and heavier, till at length it equal gold it self in weight. Now, if to mercury thus purified, you can give the proper digestion, in proper degrees; the mercury will become gold: to make gold, therefore, there are only two things required, viz. first, a consumption of impurities; and second, a fixing or converting of a fluid into a malleable solid. Now, why should the first be held impossible, when we see that lead, in a few minutes, carries off every thing except gold, and silver; and antimony, all except gold? Whether the thing be possible, or no, we will not say: but since the alchemists in other things, wherein they can be understood, use to speak the truth; they deserve some credit in this.

* See p. 100, 103.

† Further instances, and authorities, may be seen in the notes, p. 43, 44.

The alchemists only pretend to do that in a less time, which nature ^{Transmutation and the Philosopher's stone no impossibilities} does in many years: for lead and gold don't differ much as to weight; consequently there is not much in lead beside mercury. Now 'tis certain there is gold in every mass of lead: had we then a body which would so agitate all the parts of lead, as to burn every thing out but mercury and gold; and had we some fixing sulphur to coagulate the matter remaining: would not it be gold? Why then should the alchemists be so derided? 'tis from a mere ignorance of the nature and philosophy of metals. The philosopher's stone is held a fix'd, subtle, concentrated fire, which upon its melting with metals, does, by its magnetic power, immediately unite it self to the mercurial body of the metals, separates all that is impure therein, volatilizes it, and leaves the rest pure mercury.

Where is the impossibility? for our own parts we neither affirm nor deny it: but this we may rest secure of, that if any body has the secret, he won't discover it to another, so that all who pretend to have it, and to sell it others for money, plainly shew they have it not. We can't forbear however, to say, that the genuine *Adepti* have said nothing so absurd; nor is Mr. Boyle himself averie to the notion: *Helmont* says he saw it and felt it; that a friend of his gave him $\frac{1}{4}$ of a grain of this stone, which he added to 8 ounces of melted silver, and the silver was turn'd into gold, all but 14 grains, which went off in fume: and he says the like of lead, only a greater quantity thereof was lost. Now if we read the alchemistic authors, we find nothing of iron or copper thus converted into gold; whereas were the whole a deceit, it had been as easy to have taken those metals too into the account. But the philosopher's stone is never applied to any thing but silver, lead and mercury. Other philosophers laugh at 'em for calling the philosopher's stone a fix'd, concentrated fire; as thinking it a contradiction, that fire, which is the most volatile of all bodies, should be call'd *fix'd*. But such people are unacquainted with the nature of fire, nor have seen the experiments wherein we catch, hold, bind, and weigh fire, extract it out of bodies, introduce it into bodies, and retain and fix it therein*.

A second thing the alchemists seek, is a *ferment*; of the philosopher's stone, i. e. ^{Multiplicative virtue of the philosopher's stone.} such an exaltation of this stone, as that if it be fused with gold, it will convert that metal into this stone; which they call the *multiplicative power*.

A third thing they are in search of, is an *universal ferment*, that is, some ^{An universal ferment.} artificial matter, which being applied to any seed, increases its fecundity to infinity: thus if it be applied to gold, it changes the gold into the philosopher's stone of gold; if to silver, it converts it into the philosopher's stone of silver, i. e. into a matter which transmutes every thing into silver: if to a tree, the result is the philosopher's stone of the tree, which transmutes every thing into the species of trees, and so of the rest.

This, a noble traveller, far from all temptations from want of money, assured us he was master of; its intention is to increase the kinds of all things, v. gr. so to increase the quantity of wheat, as that the space now

* Of this see more in the chapter of fire.

possessed by all things in nature, should be taken up by wheat alone. But this seems repugnant to the rules of nature; it being a most certain truth, that a *seminal fabric* is only to be had from a seed. This speculation, therefore, we are but little inclined to give into.

These three things are all we could collect from all the alchemists who have ever wrote; and of these the making of gold is held much the least noble arcanum. With regard to which, it is their unanimous doctrine, that mercury is the same in all metals, only differing in degree of purity; being purest in gold, and in the rest so much the purer as the metal is purer: that mercury is the immediate matter of gold; and that if all the scoria adhering to mercury, be taken away, it will become heavier than gold it self; and in that state is call'd mercury of metals.

Of the INSTRUMENTS of Chemistry.

WE are now to consider the *instruments*, by the application whereof chemistry performs its operations.

The whole theory of chemistry, we have already observ'd, is laid down in the mere explanation of its definition; all the parts whereof are already gone thro': excepting the last, which still remains to be explained, *viz.* by what means the changes wrought in bodies by chemistry, are effected. An *instrument*, then, is a certain body, by whose application to some other body, a motion is excited therein, by which motion the change intended by the art is produced*.

An instrument,
what.

Instruments of
chemistry reducible
to six.

All the instruments of chemistry may be reduced to six; the four first whereof, are the four vulgar elements.

The 1^o, is *fire*, by which all motion is produced.

2^o, Is *air*, by means whereof motion is preserved.

3^o, Is *water*, by which motion is communicated.

4^o, Is *earth*, whereof all vessels are made.

5^o, Are *menstruums*, whereby bodies are intimately dissolved and mov'd.

6^o, Are *vessels*, wherein the bodies to be changed by fire, water, &c. are contained.

* Or, an *instrument* is a body which easily receives certain motions from other bodies, and applies 'em to the subjects intended to be changed; producing such effects therein, as the art propos'd. Boerhaave
cod. impress.

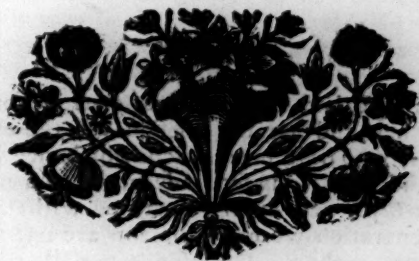
By *fire* we mean any body that rarifies the air in a thermometer : this *fire*^{Fire.} is the universal instrument of all nature, as well as of the art of chemistry. By this it is, that all bodies are moved, and it is by this that they discover their powers : If this were away, all bodies would immediately become solid and immoveable. Now there is no chemical operation without fire ; as is evident hence, that there is no place, no body but has fire in it ; and that it is absolutely impossible to exclude the fire out of any body whatever.

Air, 'tis true, we can exhaust to any degree at pleasure, by the air-pump ; *Air.* and in the *Torricellian* experiment, it is sometimes drawn out, so as not to leave any sensible resistance : in which cases, there is physically no air at all. But we have no such operations in chemistry : the air has a share in 'em all ; as having continual ingress and egress out of all our vessels, and as being included in the pores of all bodies. Air then is present in all our operations, and occasions a great change therein, by its power of rarifying, and contracting every moment, and by its alternate vibrations, whereby all bodies are kept in continual motion.

Water is scarce capable of being excluded out of any place, or body ; for *Water.* the driest, and warmest air, contains water ; and the particles of air are in reality so many magnets, which are continually imbibing water, whatever place they are in. Nay, if the air be exhausted out of a receiver, the water is in good measure left behind ; and little drops are found to fall to the bottom : the remaining air being so rarified, as not to be able to sustain the water.

Earth is present in all our operations, as being the matter whereof all *Earth.* our furnaces, vessels, glasses, fuel, &c. consist.

The doctrine of each instrument of chemistry we shall now lay down a-part.



THE
History of FIRE.

Fire held a deity.

THE nature of fire is so obscure, and wonderful, that it was held by most of the antients, as a Deity. Great pains have been taken by several authors, of prime note, to unveil this mysterious Being ; but after a careful perusal of what they have done, we find them all stick by the way, unable to explain many of the principal effects and phenomena thereof.

To get over this, we have been at no small pains in making a new set of experiments, wholly with this view ; and on the footing thereof, have laid down a new doctrine of *fire*, in a course of public lectures held for that purpose : The result whereof, we shall here deliver in a little compass*.

The instrument of all motion.

Fire, in effect, appears to be the general instrument of all the motion in the universe : the constant tenor of a great number of experiments made to this purpose, leave us no room to doubt, but that, if there were no fire, all things

* The doctrine of fire here laid down by our author, will appear new and extraordinary ; at least among us, who have been used to consider fire in the light it is set by my Lord Bacon, Mr. Boyle, and Sir I. Newton. But whatever veneration we may owe to those illustrious authors, we should be inexcusable, even in their judgment, should we absolutely acquiesce in what they have done, and shut the door against further, or even better, information. Boerhaave may be easily supposed to

have gone beyond any of them ; in that, beside all the experiments and observations which they had to build on, he has the advantage of a new set they were unacquainted withal. However, as his experiments are not yet made public ; and as, for want thereof, there appear divers things in this chapter, which may be call'd in question : we would not give it alone ; but along with his sentiments, and solutions, have chose to give the corresponding ones of the other philosophers, both

things would instantly become fix'd, and immoveable. Of this we have popular instances every winter: for while frost prevails, the water, which before was

both where they agree and corroborate, and where they clash with each other.

The great, and fundamental difference in respect of the nature of fire, is, whether it be originally such, form'd thus by the creator himself at the beginning of things; or whether it be mechanically producible from other bodies, by inducing some alteration in the particles thereof? Among the modern writers, *Homberg*, *Boerhaave*, the younger *Lemery*, and *s'Gravesande* maintain the former: the latter is chiefly supported by the *English* authors.

Bacon, in his treatise *de Forma Calidi*, deduces from a great number of particulars, that heat, in bodies, is no other than motion; only, a motion so and so circumstantiated: so that, to produce heat in a body, nothing is required but to excite such motion in the parts thereof.

Boyle seconds him, in an express treatise of the *Mechanical Origin of Heat and Cold*; and maintains the same doctrine with new observations and experiments: As a specimen, we shall here give one or two of them. Many more will come in the course of the chapter.

"In the production," says he, "of heat, there appears nothing on the part either of the agent or patient, but motion, and its natural effects. When a smith briskly hammers a small piece of iron, the metal thereby becomes exceedingly hot; yet there is nothing to make it so, except the forcible motion of the hammer, impressing a vehement, and variously determined agitation, on the small parts of the iron, which being a cold body before, grows, by that super-induced commotion of its small parts, hot: First, in a more loose acceptance of the word; with regard to some other bodies, compared with which, it was cold before: then, sensibly hot; because this agitation surpasses that of the parts of our fingers: and in this instance, oftentimes, the hammer and anvil continue cold, after

"the operation; which shews, that the heat acquired by the iron, was not communicated by either of those implements, as heat; but produced in it by a motion, great enough strongly to agitate the parts of so small a body as the piece of iron, without being able to have the like effect upon so much greater masses of metal, as the hammer and the anvil. Tho' if the percussions were often, and briskly renewed, and the hammer were small, this also might be heated. Whence it is not necessary, that a body itself should be hot, to give heat.

"If a large nail be driven by a hammer into a plank of wood, it will receive several strokes on its head, e'er it grow hot; but when it is once driven to the head, a few strokes suffice to give it a considerable heat: for while, at every blow of the hammer, the nail enters further into the wood, the motion produced is chiefly progressive, and is of the whole nail, tending one way; but when the motion ceases, the impulse given by the stroke, being unable to drive the nail further on, or break it, must be spent in making a various, vehement, and intestine commotion of the parts among themselves; wherein the nature of heat consists."

Mech. Produc. of Heat and Cold.

Agreeable to this, is the opinion of *Sir I. Newton*, who conceives that "gross bodies may be converted into light by the agitation of their particles; and light, again, into gross bodies, by being fixed therein." *Optic.* p. 318, & 349.

On the other hand, *M. Homberg*, in his *Essai du Souffre Principe*, holds, "that the chemical principle or element sulphur, which is supposed one of the simple, primary, pre-existent ingredients of all natural bodies, is real fire; and consequently that fire is coeval with body." *Mem. de l'Acad. An.* 1705.

Dr. s'Gravesande goes on much the same principle: "Fire, according to him, enters
"the

Absence of fire
the cause of
freezing.

Shewn by the
thermometer.

Air, plants, and
animals without
fire would fix
into rigid mas-
ses.

was fluid, by a mere privation of heat, becomes solid, *i. e.* hardens into ice *, and so remains till resolved again by fire. That the difference between water which freezes, and other water which does not, consists in the different quantity of fire contain'd in the one, and the other, appears hence; that if you apply a thermometer alike to a vessel full of cold water, inclining to freeze; and to another vessel full of water, one degree nearer freezing: you will find the former to have a greater degree of heat than the latter: And if a quantity of ice and sal-gem were added to either, the water would be still found much colder, and accordingly more disposed to freeze. And if from this water you remove the thermometer to the other less cold, the spirit will rise; the cause of which rising can be no other than the little fire still remaining in the water: or, to speak more precisely, the cause of the spirits being rarefied and elevated higher by the one than the other, is no other than the greater remains of fire in this, than that †. In effect, all natural motion is perform'd either by a separating of parts from each other, or by a rarefying of them; neither of which is done, but by fire.

'Tis therefore a just observation of the chemists, that *fire is the universal cause of all the changes in nature*: Thus, were a man entirely destitute of heat, he would immediately freeze into a statue. And thus, the air itself, which is found in continual motion, being always either expanding or condensing, would, upon the absence of fire, contract itself, so as to form a solid, consistent vault. So, also, all animals and vegetables, all oils, salts, &c. would upon the like occasion immediately congeal.

That fire is the real cause of all the changes in nature, will appear from the following considerations.

"the composition of all bodies, is contain'd
"in all bodies; and may be separated, or
"procured from all bodies, by rubbing
"them against each other, and thus putting
"their fire in motion. But fire, he adds,
"is by no means generated by such mo-
"tion." *Elem. Phys. t. 2. c. 1.*

M. Lemery the younger agrees with these two authors in asserting this absolute, and ingenerable nature of fire: But he extends it further. Not contented to confine it as an element to bodies, he endeavours to shew that it is "equally diffused thro' all space, is present in all places, in the void spaces between bodies, as well as in the insensible interstices between their parts. *Mem. de l'Acad. An. 1713.*

This last sentiment falls in with that of Boerhaave, which will be more largely set forth in what follows.

* Paracelsus even affirms rock-crystal to be nothing else but water strongly congeal'd by a very intense cold. But this does not appear very probable, in regard crystal is so much heavier than water; whereas ice is lighter. See the chapters of *Stones and Water*.

† Accordingly, the younger Lemery observes, that ice is only a re-establishment of the parts of water in their natural state; that the mere absence of fire is sufficient to account for this re-establishment: and, lastly, that the fluidity of water is a real fusion, like that of metals exposed to the fire; only differing in this, that a greater quantity of fire is necessary to the one than the other. *Mem. de l'Acad. Royal. An. 1709.*

1^o, Under the word *nature*, some conceive all created Beings; but in the sense we here use it, it only extends to *body*, or the aggregate of all bodies; any change wherein, we assert to be impossible, without the mediation of fire: For all bodies are either solid or fluid; the solid, of themselves, are commonly supposed to be inactive, and motionless; the fluid both move, and are moved †.

Fire the cause of all changes.

Now even all solids are found so much the more firm and contracted, as they have the less fire; as is evident in iron, which, when heated, expands into a much greater space than when cold ||. So that any solid, and hard body, by being freed of all fire, would sink into a much less bulk, and its parts cohere more nearly, and with greater force than before. Nay, Mr. Boyle suggests several considerations why even the most solid bodies should be thought to have an intestine motion. This he instances particularly in a diamond he wore, which had a spot in it, that he could sensibly perceive to change its place. This would bring solids still nearer to the condition of fluids.

In solids.

† 'Tis not a point universally agreed on, that fluidity consists in a perpetual motion of the parts of a fluid body. The *Cartesians*, 'tis true, take it for granted; and, accordingly, make this the definition of a fluid, that it is a body whose minute parts are in a continual agitation. But this appears a little too adventurous; as we cannot directly prove that there is such motion in all fluids. Sir I. Newton, therefore, proceeds more cautiously: To constitute a fluid, he only supposes it necessary "that the particles be easy to put in intestine motion, and in moving be disposed to slide over one another". Indeed, this amounts to much the same, with regard to our present purpose, as the former: for, here, such a lubricity, volubility, and mobility of the parts is supposed; as, considering the almost incessant agitations of the earth, air, &c. and the actions of the fire, &c. which will be shewn to penetrate all bodies; can scarce possibly let the particles of any fluid in nature, remain one moment in a state of rest. Accordingly, Dr. Clark takes in both opinions into his notion of fluidity: "If the parts of a body," says he, "either do not touch one another, or easily slip over one another; and be, withal, so small, as to be capable of being easily agitated by heat; and the heat be sufficient to agitate them, tho', perhaps, not sufficient to prevent their freezing: or even if they be not moved, provided they be but small, smooth, and voluble, of such figure and bulk,

"as makes them liable to be easily put in motion: that body is fluid." *Annot. in Robault. Phys.*

To say no more; the great Mr. Boyle lays down an intestine agitation of the constituent particles of a body, in various directions, either by an innate activity of their own, or by the action of some thinner medium that penetrates their pores, as absolutely requisite to fluidity. And tho' the particles here supposed to move, be too small to have their motions observed by the eye; yet that author suggests several considerations, to evince the reality thereof: The principal things he insists on, are the sensible operations of fluids; for how, says he, should they effect those solutions, putrefactions, &c. which we daily observe from them, without local motion? 'Tis true, a later philosopher accounts for those solutions, without supposing any antecedent motion in the parts of the fluid. 'Tis sufficient, with him, to have a motion occasionally excited by the mutual attraction between the parts of the fluid, and those of the body dissolved thereby. *Newton. Optic.*

|| "Fire," says Dr. Gravesande, "naturally unites itself with bodies: And hence it is that a body brought near to the fire, grows hot; in which case it also expands or swells; which expansion is not only observed in very solid bodies, but in those whose parts do not cohere; in which case they likewise acquire a great degree of elasticity, as is observed in air and vapours." *Element. Phys.*

As

In fluids.

As to fluids, they all harden, even to the eye, upon the absence of fire: Thus water, in a severe winter's cold, will form itself into a solid glebe; and yet even then, contains a great deal of fire; as evidently appears, upon application of the thermometer thereto, which is capable of falling twenty divisions lower, e'er it arrive at the point of intensest cold: And hence it is that the spirit of wine is kept from freezing in the thermometer; which would undergo the common fate of other things, were the fire in less abundance. Thus, the same degree of cold wherewith oil of olives congeals, does not freeze water: And yet water freezes, when ale will not*. Hence it is evident, that if there were no fire in nature, all bodies, both solid and fluid, would remain for ever at rest, and consequently never undergo any alteration.

So, the air itself, by a greater quantity of fire, expands; and condenses by a less†: yet, where 'tis most of all contracted, it still contains a large share of fire, as is evident from the collision of a flint, and steel‖ therein, which is followed by sparks of fire. If this fire could likewise be taken from the air; it would become solid, and perfectly at rest, and consequently incapable of change.

As, then, fire can render the most solid bodies, as stones, metals, &c. fluid, (which we evidently find in the large burning-glasses, wherein gold itself immediately calcines, and emits fumes, *i. e.* becomes fluid;) so the want of fire would convert the most fluid bodies, as spirit of wine, &c. into solids**.

And

* "The oil of vitriol be one of the most fiery liquors yet known, and even performs some of the operations of fire itself, and thaws ice sooner than the spirit of wine, or any other liquor; yet having put a pound of fine rectified oil of vitriol into a strong glass-vial proportionable to it, we found, that, except a little which was fluid at the top, it was all congealed or coagulated into a mass, like ice, tho' the glass stood in a laboratory, where a fire was constantly kept not far from it, and where oil of vitriol very seldom, or never, has before, or since, been observed to congeal so much as in part." Boyle *Mech. Prod. of Heat.*

† See the chapter of air.

‖ Sir Isaac Newton, and the English philosophers, account for the fire arising upon such collision, on a different principle. They suppose it produced by putting the sulphurous particles of those two bodies in a vehement vibratory motion; by virtue of which motion, they become hot and

lucid, *i. e.* affect us with the ideas of heat and light. But this doctrine will be further considered and explained hereafter.

** Fire, thus, being acknowledged the instrumental cause of all motion; it remains that itself be moved: nay, to move, must be more natural, and immediate to fire, than to any other body; and, hence, some have ventured to make motion essential to fire: But as this is inconsistent with the notion of matter, which is defined to be inert, and passive; and as we shall hereafter prove that fire is material: we must rather agree, that the motion of fire itself is derived from some other higher, and more metaphysical cause. A property of perpetual mobility may indeed be superadded to the other properties of fire; but it has no natural, necessary connection with them: nor can it be maintain'd with them otherwise than by some extrinsic efficacy of a superior cause.

However, that it is by motion that fire produces its effects, is evident. And hence the action of fire cannot make any alteration

And hence we gather, that fire is the only *active* or *proper instrument* of chemistry; without which, the chemist would be absolutely incapable of performing or producing any thing.

Now, fire is two-fold; the one pure, and *elementary*; which alone we here call *fire*: the other *vulgar*, raised and kindled from the former; which is what agitates and affects ignited, combustible, and moveable bodies. *Fire distinguished.*

All the authors who have wrote of fire, overlook this distinction, which has led them into grievous mistakes: insomuch that most of them hold the flame of a piece of wood to be all fire; which is absolutely false †, as will appear from what follows.

1^o, Fire may be present, in the greatest abundance, yet without any heat; as is evident in the tops of the highest mountains illumined by the *Fire without heat.*

ration in the elementary substance of bodies; for it is necessary, that what acts upon an object, be without that object; i. e. the fire must not penetrate the elementary parts, but only enter the pores and interstices of bodies: so that it does not seem capable of making those transmutations which Sir Isaac Newton ascribes to it; of which we shall speak hereafter.

In effect, as to all our purposes, it may perhaps be said, that fire is always in motion: Take, for instance, six several sorts of thermometers, and two vessels of water with sal-ammoniac mixed therein; and apply the thermometers hereto: the consequence will be, that the air being condensed in them, the spirit will descend in all: Remove the vessels of water; and the air growing warmer, and so rarefying, the spirit will ascend again. So that the active force in air which produces so many effects, does really all arise from the fire contained in it.

Again, as all bodies placed in a very cold air, do, by degrees, grow cold, motionless, rigid, &c. tho' there be still some remains of fire; and in proportion as that is diminished, the effect is accelerated: it follows, that cold, i. e. a less degree of heat, is the effect of a lesser action of fire. And so all action apparently arises from the same source.

† "The flame of a body," Sir I. Newton observes, "is only the smoke thereof heated red hot; and the smoke is only the volatile part of the body separated by the fire. Thus, all inflammable bodies, as sulphur, oil, wax, wood, &c.

"by flaming, waste, and vanish into burning smoke; which smoke, if the flame be hastily put out, is very thick, and visible, and sometimes smells strongly, but in the flame loses its smell by burning; and, according to the nature of the smoke, the flame is of this or that colour. Thus, the flame of sulphur is blue; that of camphor, white; that of tallow, yellow, &c. When gun-powder takes fire, it goes off in a flaming smoke; the explosion arises from the violent action of its ingredients, nitre, sulphur, and charcoal upon each other; whereby the mixture being suddenly, and violently heated, becomes rarefied, and converted into fume; which, by the violence of that action becoming hot enough to shine, appears in the form of flame. *Ibid.*

"Flame I take for a mixture of fire with the oily part of the fuel; and this oil, being the sulphurous part of the mixt, i. e. the part wherein the fire acts, is more disposed than any other part to admit and retain a quantity thereof. A quantity of fire, then, being enter'd into such oil, must extend its mass, and augment its bulk inasmuch as the oil is capable of stretching, and of filling, at the same time, all the interstices thereof with its own substance. Thus the mixture becomes what we call flame; which, therefore, is an oily body without pores, or whose pores are exactly filled up with the globules of fire contained therein." *Homburg. ibid.*

sun, where the cold is always extremely pinching; and this even under the Equator; mountains being there found perpetually cover'd with snow, tho' there can be no want of fire.

So, a large burning-glass, in a place where the sun does not shine, or when the sun is cover'd with a cloud, has no effect; the smallest warmth cannot be felt in its *focus*: But the moment he emerges, a piece of metal will be seen to melt.

A little fire
may burn vehemently.

2^o, Fire may be in exceeding small quantity, and yet burn with great violence: Thus, spirit of wine, when set on fire, does not burn the hands; and, tho' poured on a piece of red-hot iron, does not take fire; so that the fire therein should not appear very great. Yet, if, in burning, it meet with some other harder body, whose particles it is capable of agitating by the attrition of its own, it will yield a fierce flame, capable of burning a firmer body than the hand.

The instruments
of heat and
burning.

From this it appears, that the rotation of heterogeneous particles agitated by the fire, has more effect in respect of heat, than the action of the fire itself. Nor is the mechanical reason hereof far to seek; for the particles of fire being supposed all equal, and spherical, must of themselves be harmless; but if they carry along with them certain *spicula*, or other pointed bodies, they then become capable of doing much harm.

Hence, tho' the flame of a piece of wood may give a sense of heat, and burn things applied to it; it does not necessarily follow, that there is any pure fire therein: so that the distinction between pure and common fire, is of absolute necessity.

Elementary fire. *Elementary fire* is that we find collected in burning mirrours; as that of *M. Villette*. This fire needs no *pabulum* or fuel to sustain it, yields no smoke, emits no flame, nor yields any ashes.

Vulgar fire. *Vulgar, or common fire*, is that which we every where see excited in oil, wood, &c. How to distinguish between these, will appear from what follows.

Pure fire is found in two different manners; either as it exists every where, and diffused equally in all places; or, as it exists in certain bodies, which it makes no great alteration in.

Elementary fire
equally in all
places.

That fire should exist in the same quantity, in all places, will seem a strange paradox: and yet the thing is demonstrable from innumerable experiments.

The *Cartesians*, as *Mariotte*, *Perrault*, &c. hold, that in a perfect vacuum, *i. e.* a space out of which all the air has been exhausted, there is yet a large stock of fire; as supposing an absolute vacuum impossible. Now, the most perfect vacuum we can arrive at, is that of *M. Huygens's* contrivance, which is as follows: Heat a quantity of the purest mercury to the degree of boiling-water, and pour it into a hot tube of about forty inches long: when the tube is filled, apply a finger on the orifice thereof, and thus invert it, in a basin full of mercury. The mercury will now be suspended in the tube to the whole height; till giving it a little shake, it will sink to the height of about twenty-nine inches; and thus leave a perfect vacuity of eleven

eleven inches. Yet here, the philosophers abovementioned deny there is any *vacuum*; urging, that so much the more fire is now enter'd into the space, as before there was of other matter: But this is contrary to experience; at least, the fire there contained, is no hotter than the mercury itself. For a drop or two of water being sprinkled in a frosty season, both on the upper part of the tube supposed to be full of fire, and on the lower full of mercury; they will freeze alike in each place. So that there is no more pure fire in the most perfect *vacuum*, than in any other place.

But fire, we have said, is found in all bodies *. To prove which, set gold against the *vacuum* just mentioned; and this gold, tho' the most ponderous of all bodies, will not contain more fire than is in *Huygens's vacuum*; as appears from the thermometer. In all bodies.

But the fire in gold, when ready to fuse, is pure fire; for a mass of this metal, once heated red-hot, will retain this fire perfectly for three days: Nay, the prince of *Mirandola*, and others, have kept gold ignited for two months, without any diminution of weight. See what has already been observed on this head, p. 63, 64.

Now, this fire, of itself, always lies conceal'd; nay, where it is in the greatest quantity, it may yet be perfectly undiscoverable: as is evident in the torrid zone; where, notwithstanding the great abundance of fire, the snow in many places never melts. Elementary fire always latent.

It will scarce appear credible, that there should be the utmost degree of fire where no flame appears, nor any light is seen: and yet 'tis certain that the sun is placed in the centre of the system, and that he emits rays all around him, as far as the sphere of *Saturn*; and that the light reflected from *Saturn*, comes originally from the sun: And we all know, that when the conical shadow of our earth occasions night, the rays in their passage to *Saturn*, must travel through those immense spaces of the heavens, which yet we find involved in darkness. We see the space, but the rays we see nothing of, till they have perform'd their journey, and are some of them dispatched again to us.

* Bodies of any kind being violently moved against one another, will grow hot by such friction, and this to a considerable degree; which shews, that all bodies have fire in them. For fire may be put in motion, and separated from a body, by such rubbing; but can never be generated that way. *s' Gravesand Physic. Element.*

Quick-silver is allow'd the coldest of all fluids; inasmuch that "many," says Mr. Boyle, "deny that it will produce any heat by its immediate action on any other body, and particularly on gold: but several trials have assured me, that a particular mercury may, by

"preparation, be enabled suddenly to insinuate itself into the body of gold, whether calcined or crude, and become manifestly hot with it, in less than two or three minutes." Boyle *Mech. Prod. of Heat.*

"That quick-silver contains fire, is evident hence, that if you shake it about in an exhausted glass, it will appear all luminous. But for this experiment, 'tis necessary the mercury be very pure and defecate: if it have no tin mix'd in it, you may purge it with boiling-hot vinegar." *s' Gravesand ibid.*

Fire discover'd,

This fire, in it self thus perfectly latent, may discover it self to be present by five effects.

By the rarefaction of bodies.

1^o, By rarefying bodies, and particularly air : For we have already observ'd, that the fluidity of all liquors depends wholly on fire ; and consequently all rarefaction. There is no fire, but what rarefies air : and all oils, waters, spirits, and, in one word, all fluids are rarefied by the same cause. Nay, and solids themselves rarefy by fire : Thus a bar of iron, by the mere warmth * of a puff of breath, or the application of a hand, shall be sensibly extended.

By light.

2^o, Fire shews it self to be present by light : for wherever there is light, there is fire. The sensation of light is produced when the particles of fire, directed by the action of the sun, reach the eye in right lines. Without this circumstance of determination, fire would never be visible ; as is evident from a darken'd chamber, wherein the rays received in at an aperture of the wall, and proceeding along the chamber, are not at all seen, till being reflected from the wall, they return and strike the eye in right lines. Nothing, therefore, shines without fire ; but neither does fire shine of it self, unless it flow from the lucid body in right lines †.

By colour.

3^o, Fire discovers it self by colour : for all colour depends on light ; and light, we have observ'd, depends on fire. This, *Virgil* alludes to in that beautiful verse, where he says,

— *Rebus nox abstulit atra colores.*

And the same is proved by Sir *Is. Newton*, in his optics, by a great number of experiments. That author shews, that a single ray of light, which had always been taken for a simple body, becomes divided, by reflection, into a great number of rays, of divers colours ; and this in a constant law : and that 'tis only as bodies are disposed to reflect this or that sort of colour'd rays more than others, that they appear of this or that colour : without such colour in the rays of fire, all bodies would remain invisible ; so that all we see in

* Thus *s'Gravesand* : " All bodies are dilated by the action of fire ; but the degree of such dilatation, seems rather to depend on the motion, than on the quantity of fire. For bodies are expanded by rubbing, as well as the application of fire externally. *Element. Phys.* From this expansion it follows, that the constituent particles of bodies, acquire a repelling force by the action of fire ; in virtue whereof, they endeavour to recede from each other, with a tendency contrary to that of attraction. While this last force remains stronger than the other, the particles cohere more or less, according to the less or greater degree of heat : When the repelling force is almost equal to the attraction, the particles before firmly join'd, scarce cohere, yield to the small

least impression, and are easily moved among each other : And thus it is, that a solid becomes a fluid by heat. The effect may be so increased in some bodies, as that the attracting force shall be overcome by the repelling force, in which case the particles fly from each other : and thus it is that heat volatilizes bodies. *Id. ib.*

† Thus *s'Gravesand* : Fire entering the eye in right lines, gives a motion to the optic fibres at the bottom of the eye, and thus excites the idea of light. That light can have no other motion but a rectilinear one, appears from the stopping or intercepting it by a body directly interposed between the luminary and the eye ; and hence a body is said to be *lucid* or *luminous*, when it gives fire a motion in right lines. *Ubi supra.*

bodies,

bodies, is fire alone : which is a paradox first demonstrated by Sir *J. Newton*. The truth is, the different colours of objects arise merely from the different reception of the rays of light, the different divisions they make thereof, and the different parts they retain and repel ||.

4^o, It discovers it self by *heat* : fire is never without both heat, and light ; By *heat* tho' it's possible for those to be in so small a degree, as not to be sensible. Thus, by the attrition of mercury in a glass vessel, and a dark place, it presently emits light ; but if this be done in a place illumined, no light is seen ; and yet there is the same light on the part of the luminary, as in the former case. So if you grind a little mercury and fine glass together, the glass will presently grow both hot and luminous ; and the same obtains in sugar, and other bodies, which when at rest emit no light, but by rubbing, readily do : and yet such bodies are not hot ; for if you shake a little mercury in a clean glass vessel, it shall shine, tho' it does not afford any indication of heat when applied to the thermometer : so that a sensible light may arise, before there be any sensible heat. On the contrary, if you take two pieces of iron, and rub one against the other in a dry air, they will grow extremely hot e'er they shine at all ; but with further friction will shine sensibly enough. So that light does not constantly either precede or follow heat ; but both are present at the same time, tho' not both alike sensibly.

And hence fire is divided into *lucid* and *not lucid* ; to shine, not being any native, essential property of fire ; but depending on the various determinations thereof. *Light or shining not essential to fire.*

Thus if you hang up several different colour'd clothes, in a dark place ; some white, others red, and others black ; and place your self at a little distance : you will perceive nothing at all where the black are ; where the white are, there will something appear ; so also where the red are, tho' less than where the white. Not that there is more fire in one than another ; but one reflects more or fewer rays than another ; so that the cir-

|| Natural bodies only become of different colours, as surfaces are disposed to reflect differently colour'd rays ; and a body appears of the colour which arises from the mixture of the rays reflected by it. Thus placing two bodies, *e. gr.* a red and a blue one in the dark, where neither of 'em is visible ; and enlightning 'em successively by rays transmitted thro' a prism ; they will then be seen, and each of the sorts of colour'd rays, will be reflected from each : But the red rays will be much the most copiously reflected from the red body, and the blue from the blue. And enlightning 'em both with only one sort of rays, *e. gr.* red ones ; the red object will be very vivid, and the blue scarce visible.

To determine the precise constitution of

the surface of bodies, whereon their colour depends ; it is to be observed that the smallest particles of all bodies are found to be transparent ; and that they are separated by a medium of a different density from the particles themselves : and hence, in the surface of every colour'd body, we may conceive innumerable, small thin lamellæ, or plates. But it is demonstrated of such plates, and consequently of the surfaces of bodies, that their colour depends on the thickness, and density of the parts or plates in the surface, between the pores thereof ; that the colour is so much the more vivid and homogeneous, as the plates or parts are thinner ; and that, *ceteris paribus*, the said parts are the thickest, when red ; and thinnest, when violet.

cumstances

circumstances of light do not depend on fire, so much as on the surface of the body that reflects it.

Heat or warming not essential to fire.

Heat no standard of the degree of fire.

Fire discovered by burning.

Further experiments and considerations to prove fire in all places and all bodies, alike.

Lucid fire, again, is of two kinds, *viz.* that which *warms*; as red-hot iron: and that which does *not warm*, as that in rotten fishes; the oils whereof being attenuated enough to rub against one another, yield light, but without any heat that the barometer takes cognizance of. But heat is our own sensation; nor is it to be deem'd a just measure of the quantity of fire: Thus, a man coming out of a hot bath, even into a moderately warm air, will seem as if he were come into an excessively cold place; and another entering a warm room, in a cold winter's day, will at first fancy himself in a stove. This shews, that the sense of heat does by no means determine the exact degree of fire; as being always relative to our bodies: And hence, some persons scarce perceive the severest cold; and others, on the contrary, the most sultry heat: so that the degree of heat depends on a comparison of the person who perceives it*.

5°, Fire discovers it self by burning †.

From what has been said, we may infer a very remarkable property of fire, and which every body will esteem as a paradox, *viz.* that fire is present every where. Pure, or elementary fire, we assert, is equally present in all places; nor is there any point of space, or any body, wherein there is more found than in any other.

For we have already shewn, that there is the same degree of fire in the most perfect vacuum in nature, as in the most solid body; in mercury, as in oil of vitriol; and that it is equally present in ice or snow, as the purest spirit of wine: and hence we argue, that there is a good quantity of fire even in the coldest places, and the coldest bodies; which is further confirmed from the following experiment.

Take two large iron planes, and rub 'em briskly against each other, in Iceland, which is only 12 degrees short of the North Pole, in the most frosty season, and at midnight; and they will grow warm, glow, shine, and heat to such a pitch, as not only to rarefy the spirit in the thermometer, but even to ignite, and at last to fuse. Now, the fire here found, is either created *de novo*, or it was there before: But its creation, no body will assert; and accordingly unless a proper fuel be furnished it, it is soon dissipated again;

* A body is only sensibly hot, when the degree of its heat exceeds that of our organs of sense; so that there may be a lucid body, without any sensible heat; and consequently, as heat is only a sensible quality, without any heat at all.

Heat, in the hot body, says *Gravesande*, is an agitation of the parts of the body, made by means of the fire contained in it; by such agitation a motion is produced in our bodies, which excites the idea of heat in our mind: so that heat in respect of us is nothing but that idea; and in the hot body, nothing but motion. If such

motion expel the fire, in right lines, it gives us the idea of light; if in a various and irregular motion, only heat.

† The minute parts whereof a body consists, being vehemently agitated by attrition, the application of external fire, or the like cause; the fire contained therein is separated from those particles, and turn'd loose in the body: where, by the attraction between the particles of the fire and of the body, a mutual action arises; by which some parts are torn off from the body, and carried away by the motion of the fire. *s'Gravesand, ubi supra.*

not

not annihilated : Consequently it pre-existed : and that it is true fire, appears from its rarefying the spirit in the thermometer. Fire, therefore, which before existed, in such a diffused and dispersed state as not to be sensible ; being now collected by the attrition, becomes perceivable by the senses.

So if two bodies be so briskly moved against each other, as that no other ambient matter, but fire, on account of its wonderful subtilty, can follow 'em with equal pace ; they must necessarily collect the fire, before vague and dispersed. And thus it is that the wheels of chariots, and other vehicles, by their excessive velocity take fire ; and that balls exploded in the night-time out of great guns, grow hot in their passage thro' the air, so, as sometimes to appear ignited *.

The experiment abovementioned, with iron planes, does not succeed so well in summer, as winter : the reason is owing to the diminution of elasticity in bodies, by heat ; whereas cold augments it. Hence it is, that M. *Villette's* mirror burns more forcibly in winter than in summer ; nay, and that to have it burn with its utmost vehemence, the hind part of the mirror is to be very cold.

I have heard it alledg'd, that the iron planes, in the experiment above recited, are themselves converted by the friction into fire. But is this possible, and yet the iron remain without the loss either of bulk or weight, and return, in a few minutes, into its primitive form ? But, that fire is equally diffused every where, will appear from another incontestable experiment. The utmost effect, the greatest fire is capable of producing, is, in a moment's time to turn a flint into glass ; which effect is peculiar to M. *Villette's* mirror, and is what M. *Tschirnhausen's* burning-glass will not perform : a lime-stone, which would endure the utmost effort of the hottest furnace for many months, being exposed to the mirror, instantly passes, with a little hiss, into glass. Now this we may lay down as the ultimate degree of fire known among us : and yet we assert, that this same degree of fire is found every where. For if, even in *Iceland*, in the middle of winter, and at midnight, a steel and flint be but struck against each other, with a piece of paper underneath ; a spark of fire will fly off, which falling on the paper, will be found, by the microscope, to be a perfect globule of

* " A bullet shot out of a good wind-gun, against a metalline plate, Mr. Boyle found would be flatted almost into the figure of an hemisphere. The same author going to take up the bullet, found it too hot to be, without pain, held betwixt the fingers. *Effects of lang Mot.*

|| " M. *Villette's* burning concave is 47 inches wide, and ground to a sphere of such a radius, that its focus is about 38

inches from the vertex of the glass. The metal of it is a mixture of copper, tin and tin-glass. This concave melted iron-ore in 24", began to calcine talc in 40", and, as M. *Villette* said, would calcine *asbestos*. It melted a sixpence in 7 $\frac{1}{2}$ ", and a penny in 16". It turned an emerald into a substance like a turquoise-stone, and diminished a diamond, that weigh'd 4 grains by $\frac{1}{2}$, of its weight. *Philos. Trans. N^o. 360*

glass.

glafs †. Whence it follows, that there is the same degree of fire in the cold regions of *Iceland*, as in *Villette's* burning-glass; the same effect being produced in both.

Hence, as the same experiment succeeds alike in all places, and at all times; there is no doubt, but that fire is always found in all parts of space, and in all bodies: equally spread on the utmost top of the highest mountain, as in the subject valley, or in the deepest cavern under ground; in every climate, and at every season.

We add, that the same quantity of fire is found in all bodies, how different soever in texture, consistence, solidity, &c. Thus applying several bodies, *e. gr.* alcohol of wine, quicksilver, oil, iron, gold, &c. to so many thermometers for a whole night, the spirit was found, next morning, at the same height in 'em all.

Fire only appears when collected.

Hence we draw an inference of the last importance, *viz.* that *fire only becomes apparent, by being collected*, or gather'd nearer together. So that there is no exciting, producing or making of fire, or even putting it in motion; but the whole of what we do, is to collect what was before dispersed, and bring it into a narrower compass ||.

Fire,

† “By an almost momentary percussion, with no great force, the parts even of a vegetable may not be only intensely heated, but brought to actual fire; as we have tried by striking a good cane with a steel, or the back of a knife; for upon this collision, it would yield sparks like flint. So likewise by scraping a good loaf of sugar, with a knife, numerous sparks will be produced; but upon the collision of a flint and steel, not only fire, but even vitrification, which the chemists esteem the ultimate action of fire, is instantaneously produced: for the sparks which here fly off, are usually real and permanent parcels of stone, vitrified by the vehemence of the motion. And that this vitrification may be of the stone it self, tho' steel is of a far more fusible nature, I am induced to think, because flints will, by collision, strike fire with one another. The like also may be done with rock-crystal, and even with diamonds, on the mill whereby they are cut; tho' fire is not allowed to fuse them. *Boyle, Effects of languid Mot.*

|| Hear what the philosophers on the other side the question have to say. “That heat is mechanically producible, appears probable from a consideration of its nature;

which seems principally to consist in that mechanical property of matter call'd *motion*; but which is here subject to three conditions, or modifications.

“First, the agitation of the parts of the body must be *vehement*; for this distinguishes the bodies said to be hot, from those which are barely fluid: thus the particles of water, in its natural state, move so calmly, that we do not feel it at all warm, tho' it could not be a liquor, unless they were in a restless motion; but when water comes to be actually hot, the motion manifestly, and proportionably appears vehement, since it does not only strike our organs of feeling briskly, but ordinarily produces numerous very small bubbles, melts coagulated oil cast upon it, and affords vapours, which by their agitation ascend into the air. And if the degree of heat be such as to make the water boil, then the agitation becomes more manifest, by the confused motions, waves, noise, bubbles, and other obvious effects excited therein. Thus in a heated iron, the vehement agitation of parts may be easily infer'd from motion, and the hissing noise it makes with the drops of water that fall upon it.

“But

Fire, then, is a body *sui generis*, not creatable, or producible *de novo*, by any natural or artificial means. Its quantity is fix'd, and invariable; and the utmost that we can do with it, and which has led us to think it producible, is, that of insensible, it may be render'd sensible; where before there was

"But tho' the agitation be various as well as vehement, there is yet a third condition required to make a body hot: which is, that the agitated particles, or at least the greatest number of them, be so minute, as to be singly insensible. Were an heap of sand to be vehemently agitated by a whirlwind, the bulk of the corpuscles would keep their agitation from being properly heat; tho' by their numerous strokes upon a man's face, and the brisk commotion of the spirits, and their small particles, which may thence ensue, they may perhaps produce that quality.

"The second condition is, that the determination be very various, and tend all manner of ways. This variety of determinations appears to be in hot bodies, both by some of the instances already mentioned, and especially that of flame, which is a body; by the dilatation of metals when melted; and by the operations of heat, exercised by hot bodies upon others, in what posture or situation soever the body to be heated thereby is applied to them: thus a coal thoroughly kindled, will appear on all sides red, and melt wax, and kindle brimstone, whether the body be applied to the upper, the lower, or to any other part of it."

Hence if we duly attend to this notion of the nature of heat, 'tis easy to discern how it may be mechanically produced several ways: for, except in some few anomalous cases, by whatever means the insensible parts of a body can be put into a very confused and vehement agitation, heat will be introduced into that body. And as there are several agents, and operations, by which the heating motion may be excited; so there must be several mechanical ways of producing heat. Various experiments may be reduced to almost each of these heads; chance it self having,

in the laboratories of chemists, afforded several phenomena, referable thereto. Boyle, *Mechan. Orig. of Heat*.

Consistent with this, is the system of the Lord Bacon: that noble author is so far from imagining any particular body necessary to exhibit the phenomena and effects of fire, that he undertakes to assign precisely the mechanical cause of heat, and point out the means necessary to generate it in any body, without supposing any pre-existent fire at all.

From a particular enumeration of the several phenomena and effects of heat, he deduces, 1^o, That heat is motion: not, that motion generates heat, or heat motion; tho' in many cases, this be true: but that the very thing heat is very motion, and nothing else. But this motion he shews, has several peculiar circumstances which constitute it heat. As, 2^o, That it is an expansive motion, whereby a body endeavours to dilate or stretch into a larger dimension, than it had before. 3^o, That this expansive motion is directed towards the circumference; and at the same time upwards; which appears hence, that an iron rod being erected in the fire, will burn the hand that holds it, much sooner than if put in laterally. 4^o, That this expansive motion is not equable, and of the whole, but only of the smaller particles of the body; as appears from the alternate trepidation of the particles of hot liquors, ignited iron, &c. Lastly, that this motion is very rapid.

Hence he defines heat "an expansive undulatory motion in the minute particles of a body, whereby they tend with some rapidity, towards the circumference, and at the same time incline a little upwards." Hence, again, he adds, that if in any natural body, you can excite a motion whereby it shall expand or dilate it self; and can so repress and direct this motion upon it self, as that the dilatation

H h

shall

was no sign of it, it may be made manifest. But this, as already intimated, is only effected by determining and collecting it; by bringing it out of a larger space into a less, and driving or directing it upon this body or that. For as to the fire it self, we shall hereafter shew it a most minute, solid, simple, penetrative body: and consequently far out of the reach of our imitation.

Sir *Is. Newton*, indeed, suggests that gross bodies and light are convertible into one another: fire, he conceives, to be no more than the minute corpuscles of some fix'd body, violently agitated; and thinks the matter of any body capable of becoming fire, by a sufficient attrition. But that a body, which before was not fire, should by attrition become real fire, and at once be invested with so many singular properties, which no other body has, *v. gr.* light, colour, different refrangibility, &c. of its sides; appears to us inconceivable; and requires further proof, which that illustrious author does not pretend to give. The only argument he produces, is the conforma-

shall not proceed uniformly, but obtain in some parts, and be check'd in others; you will generate heat. *De forma Calidi.*

This system is further supported by Sir *Is. Newton*, who does not conceive fire as any particular species of body, originally endued with such and such properties. "Fire, according to him, is only a body much ignited, *i. e.* heated hot, as to emit light copiously: what else, says he, is a red-hot iron than fire? and what else is a burning coal than red-hot wood? or flame it self than red-hot smoak? 'Tis certain, that flame is only the volatile part of the fuel heated red-hot, *i. e.* so hot as to shine: and hence only such bodies as are volatile, *i. e.* such as emit a copious fume, will flame; nor will they flame longer than they have fume to burn. In distilling hot spirits, if the head of the still be taken off, the ascending vapours will catch fire from a candle, and turn into flame. So several bodies much heated by motion, attrition, fermentation, or the like, will emit lucid fumes, which, if they be copious enough, and the heat sufficiently great, will be flame; and the reason why fused metals do not flame, is the smallness of their fume; for that spelter, which fumes more copiously, does likewise flame. Add, that all flaming bodies, as oil, tallow, wax, wood, pitch, sulphur, &c. by flaming waste, and vanish into burning smoak. *Opticks.*

"And do not all fix'd bodies, when heated beyond a certain degree, emit light, and shine; and is not this emission perform'd by the vibrating motion of their parts? and do not all fix'd bodies, when heated beyond a certain degree, emit light and shine? and is not this emission perform'd by the vibrating motions of their parts? and do not all bodies which abound with terreftrial, and sulphurous parts, emit light as often as those parts are sufficiently agitated, whether that agitation be made by external fire, or by friction, or percussion, or putrefaction, or any other cause? Thus seawater in a storm, quicksilver agitated *in vacuo*, the back of a cat, or neck of a horse obliquely rubb'd in a dark place, wood, flesh, and fish while they putrefy, vapours from putrefying waters, usually call'd *ignes fatui*, stacks of moist hay or corn, glow-worms, amber and diamonds by rubbing, scrapings of steel, struck off with a flint, &c. *Ibid.*

"—Are not gross bodies and light convertible into one another; and may not bodies receive much of their activity from the particles of light, which enter their composition? I know of no body less apt to shine than water, and yet water by frequent distillations changes into fix'd earth; which by a sufficient heat may be brought to shine like other bodies. *Ibid.*

bleness of such conversion (of light into bodies, and bodies into light) to the course of nature, which seems delighted with such transformations.

We have now proved the equable distribution of fire in all places; whence it should follow, that there is the same degree thereof every where: which would really be the case, were it not that fire happens, by one means or other, to be more collected in one place than another. The manner of this I conceive to be as follows: suppose a certain quantity of fire, *e. gr.* 100 particles, contained in the space of a cubic foot, and equally diffused throughout the same. Here, each assignable point of space will have that degree of fire, which such an allotment will afford, *i. e.* the effect of the fire will be proportional to its quantity. If, now, those 100 particles be before diffused thro' such space, by any means be driven into one side of that cubic foot; or if they be collected into the space of one inch: then, that same fire, thus brought nearer, will have much greater effects, *i. e.* will become more sensible; and that in the inverse ratio of the space it possesses.

Whence the difference of fire in different places.

This collecting of fire is also confirm'd by experiments; which make it appear, that if the stock of fire in any place be larger than ordinary, the neighbouring places have so much the less; and that to freeze water the soonest possible, a huge fire should be made; after which, placing the water just without the door, it will shoot into ice, without delay. Thus if you build a very large fire in some spacious place; the neighbouring places will be found to have so much the less, as the fire burns the more strongly. And hence it is, that at some times and seasons, we feel such a vehement heat in our part of the globe, and at other times scarce any; a greater, sometimes, and sometimes a less adventitious stock being sent us from other parts. Hence it also is, that the windows of stoves, and hot houses, are so often cover'd with ice.

Some may here object those experiments of Sir *Is. Newton*, whereby he endeavours to shew that fire may possibly be more attracted by some bodies than others: but, with the freedom that becomes a philosopher, I here answer, that there is no body known, which being placed in a temperate air, has more fire than any other*. Indeed, most people imagine, that feathers, *e. gr.* are warmer than mercury; but the thermometer may convince 'em of their mistake. Thus petrol, spirit of wine, &c. are in reality no hotter than water; and the like may be said of all other bodies: so that we doubt very much whether there be any such thing as bodies that properly attract fire; or that are, with respect to fire, what a magnet is to iron.

All other bodies, we allow, have their proper magnets or attractives; *No attractives* as air, for instance, waters, earths, &c. but for fire, we know of *of fire*.

* *Quousque autem hoc assertum cum iis quae de calce viva, phosphoro, corporibus nigris, catervisque, quae ignem quodammodo haurire, figere, detinere videntur; a Newtono, Boyleo, Lemerzio, atque ipso etiam Boerhaavio, postmodum notata, consistat: auctor ipse videat.*

none *. And however something might be inferr'd to the contrary, from what *Roemer*, and *Newton* have shewn of the velocity of light, and the refraction of its rays; yet, those authors hold attraction to be always in the ratio of the density of bodies, whereas we have demonstrated that the densest of all bodies, gold, has not more fire than the most perfect vacuum.

And this gives us occasion to adore the infinite wisdom of the great creator. For had there been any thing that attracted fire; it would have become a perpetual furnace: and how unhappy must the condition of man have been under such circumstances?

Two sources of fire.

However, the equable diffusion, &c. of fire, thro' all the mundane space, does not hinder, but that to our senses it appears very unequally in different places; and hence we have two vulgarly reputed sources, or funds of fire, viz. in the sun, and the centre of the earth.

The sun.

For the first, we have the concurrent opinions of the philosophers of all ages; except one, who held the sun to be cold.

The centre of the earth.

As to the central fire, tho' our observations do not go so far; yet this is manifest, that there is an ample proportion of fire under ground; and even that fire appears much more abundant there than on the surface: so that at least a *subterraneous* fire must be granted.

Subterraneous parts the hotter the deeper they are.

Thus, they who dig mines, wells, &c. constantly observe, that while they are yet but a little below the surface, they find it a little cool; as they proceed lower, it grows much colder, as being then beyond the reach of the sun's heat; insomuch that water will freeze almost instantaneously, and hence the use of ice-houses, &c. But a little lower, viz. about 40 or 50 foot deep, it begins to grow warmer; so that no ice can bear it; and then the deeper they go, still the greater the heat: till at length it endangers the stoppage of respiration, and puts out their candles †. If they venture yet further with

with

* "Sir *Is. Newton*, however, shews, "from a great variety of particular experiments, that bodies do act on light, at "a distance; and by their action inflect "and bend its rays; which action, *ceteris paribus*, is strongest at the least distance. "He adds, that in passing by the edges "and sides of bodies, the rays bend several times backwards and forwards with "a motion like that of an Eel: and that "the rays which are either refracted or "reflected, begin to be bent before they "arrive at the reflecting or refracting "bodies. *Optice*.

"As attraction is stronger in small magnets than great ones, in proportion to "their bulk; and gravity is greater, on "the surfaces of small planets than on "those of great ones; and small bodies "are agitated more by electric attraction

"than great ones: So the smallness of the "rays of light may contribute much to "the force of the agent whereby they are "inflected, &c. *Id. ibid.*

† *Morinus*, a French author, who had the curiosity to descend himself into the mines of Hungary, some of which are; or 400 fathom deep, relates, that after he had descended about 100 fathom, he came into a very warm region of the earth, which lasted to the bottom of the mine; being so hot both in winter and summer, that the labourers usually work without their clothes: he adds, that he himself was scarce able to bear the heat. He was further told by the overseers, that 'twas universal; the lower they descend beyond 100 fathom, the hotter it still growing.

Mr. *Boyle*, however, having been to the

with a lighted candle, the place shall be immediatly found full of flame: as once happen'd in the coal-pits in *Scotland*; where a hardy digger descending to an unusual depth, with a light in his hand; the fumes, which were there found very copious, caught fire thereby, (they being no other than oil or sulphur greatly rarefied and volatilized by heat) and burnt the whole mountain down.

It seems, therefore, as if nature had lodg'd another sun in the centre, to *Central sun.* contribute, on its part, to the giving of motion to bodies; and to the promoting of generation, nutrition, vegetation, germination, &c. of animals, vegetables, and fossils; and that all productions, under ground in particular, as of metals, salts, &c. are wholly owing thereto.

How this subterraneous sun arose, may admit of some doubt; whether *How form'd.* it were form'd there from the beginning, like the sun in the firmament; or gradually produced by a secondary collection of vague fire into this place? What pleads in favour of the former opinion, are volcanoes, or burning *Whether ab ori-* mountains, which appear to have existed from the first ages: for *Ætna's* *gine.* flames are spoke of among the antient poets, as even then of great antiquity. And such mountains are found in the coldest regions, viz. *Nova Zembla*, and *Iceland*; as well as the hottest, as *Borneo*, &c. †

In behalf of the other opinion it is urg'd, that such source of fire might *Or by secondary* have arose there in time, on the principle of gravity. For tho' fire be by *causes.* nature equally disseminated every where; yet, as we shew it to be a body, and invested with the other properties of body; it must have weight; and in consequence thereof must have a tendency toward the centre. Hence it must be accumulated deep under ground; and the more so, the nearer the centre, which may be esteem'd the common seat or receptacle it all tends to. This may receive some confirmation hence, that the central space is allowed to be possessed by the heaviest and most solid bodies; but we know of nothing to enter the pores of those bodies, and make 'em more solid than others, except fire.

the bottom of some mines himself, suffices, that this degree of heat, observed in the *Hungarian* Mines, might in great part proceed from the peculiar nature of the place, or of the minerals generated there; and not wholly from their depth. Very credible eye-witnesses have assured him, that in some parts of *England*, they dig up large quantities of a kind of mineral, supposed to be vitriolic, which, by the bare addition of common water, will grow so hot as almost to take fire: so that the *Hungarian* mines being deep, and not destitute of water, it may be suspected, that either this fluid, or some peculiar mineral spirit, or juice, may with

the mineral produce a warm steam, which for want of sufficient vent, in those close places, yields a considerable heat. *Hist. of Cold.*

† "It cannot be reasonably pretended, "that the subterranean heat proceeds "from the rays of the sun; since they heat "not the earth above 6 or 7 feet deep, "even in the southern countries. And if "the lower part of the earth were, of its "own nature, cold, and received the "heat it affords, only from the sun and "stars; the deeper men descend therein, "the less degree of heat and steams they "would meet with. *Id. ibid.*

Upon

Upon the whole, in the first view, there should be two great fires, an upper or *solar*, and a lower or *central* one; in all respects alike, and the same with each other; according to the dogma of *Trismegistus* above recited. On the second view, the central and subterraneous fire is not original and elementary, but determined and collected fire; such as we have it on various occasions about the surface. It may be added, that the denying vent or passage to this subterraneous fire, appears to be the cause of earthquakes; those usually arising upon a volcano's appearing to be stopp'd up, or ceasing its eruptions; and going off again, upon its opening, or burning afresh.

Two ways of Collecting Fire.

Fire may be collected in two manners, 1^o, By a luminary determining its rays into a parallelism; and 2^o, By attrition.

The sun collects
fire.

1^o, Fire, as already observ'd, is collected, when by any means a quantity thereof is driven into a lesser compass; it being part of the character of fire, that it spreads it self equally; so that if left to it self, would be found no more here than there, and consequently would be insensible every where. But if, by any cause, it be directed toward any certain part, then it discovers it self: and such a cause is the *sun*, which revolving, with prodigious velocity, around his axis, directs the impervious corpuscles of fire, every way, in parallel right lines, and determines 'em toward certain places.

Does not emit it.

The sun, therefore, does not produce or emit fire, but only puts it in motion in right lines, and thus collects it. And hence it is, that we perceive fire so long as the sun is above the horizon; and upon his setting, lose it again; by reason, as his action ceases, the fire again spreads it self all around $\parallel$. Tho' a candle, torch, or the like, may sometimes supply his absence,

¶ " The sun, according to that excellent chemist, the younger *Lemery*, seems to be no other than a huge mass, or collection of the matter of fire, or light; tho' placed at such a distance, as to disable it to act on bodies here on earth, otherwise than by one of these two ways: first, by emanations or emissions of his own substance, transmitted hither: but this hypothesis being subject to great difficulties, and not sufficiently answering to certain phenomena, recourse is had to another; which supposes trains of fire, or light, disposed in all the interstices of the grand expanse of air and æther between the sun and us; and that these trains are made to act on ter-

" restrial bodies, by their being vigorously driven, or impell'd towards such bodies, by the immediate action of the sun thereon. These trains in effect may be esteem'd as a sort of little suns prolonged, but always depending on the great sun, as the source of their motion, and action on bodies: 'tis these that form the rays of light; they do not, in point of matter, differ from the substance of the sun himself; but only in this, that the same thing is more copious, in one case than the other. In the sun we may suppose the matter of light more abundant than in the focus of our largest burning glasses: Thus, from the vehement action of the rays of the sun, collected in such glass,

sence, by impelling, after the same manner, the dispersed corpuscles of fire, and collecting 'em into parallel rays.

Not that there is less fire in our hemisphere in the night than the day. ^{Fire as copious in the night as the day-time.} time: but light; unless it come to us in right lines, is it self invisible. Thus, in a clear, still night, we see the stars and planets shine; while the sun, being under us, is all the while dispensing his light as far as the utmost orb of *Saturn*; and yet in all its passage thro' that immense space, we see nothing of it, nor does any part thereof appear, but those few rays reflected back in right lines to our earth. The heavens, in reality, are never more illumined, than when to us they appear wrap'd up in darkness; which consideration is further confirmed from what has already been observed of a darken'd chamber.

Light, therefore, only acts according to parallel lines: nor does the sun ^{Whence the sun's warmth.} warm us, as he emits rays; but as he gathers the dispersed fire into parallel lines, and renders 'em more sensible: so that the fire is not at all the less, be the darkness ever so great. So we find the spirit in the thermometer somewhat higher in the day than the night; but if the sun shine directly on it, it then rises still much higher: not that the fire is a whit increased, by the sun, but because it is thereby determined upon the glass.

Hence we deduce the following corollaries.

1^o, That there may be the most vehement fire, without any light.

Thus, in the focus of *M. Villette's* mirror, where a sword is instantly ^{Fire without light.} vitrified; we see no more light than in any adjacent part; so that if a man, distrusting his eyes, should but apply his hand to the same, it would straight be reduced to a coal.

Nor does iron it self shine, till red-hot; tho' able, long before, to consume wood, bones, &c.

2^o, There may be the brightest light without any heat. *Dr. Hook* first ^{Light without heat.} tried the effects of a burning glass, and a concave mirror in the night-time. Upon opposing 'em to the moon, and collecting her rays, in a clear winter-night, he gather'd a light, which would immediately have blinded the best eye, by only looking at it. And yet by the thermometer, it appear'd that the heat was nothing more intense there, than in any other part of the ambient air*.

We

"glass, we learn what use the air interposed between the rays of light, is of, in tempering their action, and rendering it more supportable; since, without such medium, instead of warming, and illumining, it would blind and burn us. So that the air may be considered as having somewhat of the same effect, with respect to the rays of light falling

"upon us, that the water in a *balneum mariae* has. *Mem. de l'Acad. An. 1713.*

* If a burning mirror be held at a proper distance from you, in the night-time, so that the face be in its focus; a considerable warmth will be felt; which warmth does not arise from the common or vague external fire, but from that emitted from the body, which is collected in the cavity.

Fire always in motion.

We come now to shew, that this fire thus equably dispersed, is in continual motion, and never at rest †. This is easily proved: for if the fire be so diminished, as that the mercury in the thermometer sinks to 30 degrees, it will be frost; and yet, then, it is still capable of sinking to no degrees: consequently, there is such an expansion yet subsisting in the liquid.

Hence it follows, that this fluidity of the spirits requires a degree of fire, since 'tis the action thereof, by which it continues fluid, and therefore the fire is even then in motion.

Again, animals of all kinds live even in the most piercing cold: and the spirit it self remains fluid. All which plainly evinces the perpetual mobility of fire.

Fire in ice.

Who would imagine that there should be fire even in ice? and yet I have made an artificial cold greater by 12 degrees, than that of ice; so that had the thermometer, wherewith the extremest cold was measur'd, been applied to ice, the spirit therein would have risen 12 degrees ‖.

All fire naturally vague and undetermined.

Now this motion of fire is perfectly indifferent, and without any particular determination this way, more than that. Thus much we easily gather hence, that fire has no particular attractive, and that there is no other cause to induce it to go to one place, rather than other.

And hence, unless either the action of the sun, or some attrition intervene, to determine, and collect the fire; it would always remain the same in all places. Hence also it is, that a living man is warm even in the severest cold; and a dead one, cold in the most sultry heat.

Nature of the sun.

It were foreign to our purpose here, to enter into a particular discussion about the matter of the sun, and whether it be fire. To us it appears very extraordinary, that the sun, after a continual emission of corpuscles of fire upwards of 5000 years, should not yet be exhausted *. 'Tis much safer to say,

ty of the mirror, and reflected. Hence, if our eyes were a good deal sharper than they are, and much more easily affected, we should see a continual light streaming from us both by night and day. So that the human body is a sort of luminary or radiating fire, tho' a very weak one. Boerhaave, cod. impress.

† Il est donc constant que la Matiere de la Lumiere est continuellement en mouvement, & agissante sur tous les corps poreux que sont dans l'univers. Homberg, Essai du soufre principe.

‖ "It seems extravagant to talk of heating cold liquors with ice; but I have easily done it, by taking out of a basin of cold water, wherein several fragments of ice were swimming, one piece or two, which I perceived very well drenched with the liquor, and suddenly immersing them into a wide-mouth'd

"glass, of strong oil of vitriol: for the
"menstruum presently mixing with the
"water which adhered to the ice, produced in it a brisk heat, sometimes with
"a manifest smoke; and that suddenly
"dissolving the contiguous parts of the
"ice, and those the next, the whole ice
"was soon reduced to water; and the
"corrosive menstruum being, by two or
"three shakes, well dispersed thro' it, the
"whole mixture would immediately
"grow so hot, that sometimes the containing vial could not be endured in
"one's hand. Boyle, Mech. Prod. of Heat.

* "The sun and stars, according to
"Sir I. Newton's conjecture, are no other
"than great earths, vehemently heated;
"for large bodies, he observes, preserve
"their heat the longest, their parts heating one another; and why may not
"great,

say, that it has the power of determining fire, than that it furnishes it. The case may be the same as in M. Vilette's mirror, which when exposed to the naked sun produces such amazing effects, and yet has no effect at all, if the sun be but cover'd from it, by the interposition of a cloud, or the like: the mirror may appear the cause of burning; but 'tis only an instrument necessary thereto: and the sun may be no more.

If now the sun impel the matter of the fire, in right lines, we call it *lux*, light; which light is not any fiery corpuscles, in the sun it self, but the vague fire abovemention'd, put in a new determination by the sun, and collected into some one place. For, as already observed, the intensest light, without this determination, will leave us in the utmost night.

This fire, again, will never yield light, unless directed, and impell'd in right lines.

After the same manner arises what we call *lumen*, lustre, which is light it self directed by a luminary, and again reflected from an opaque body. For light to produce a lustre, 'tis necessary it be likewise reflected in right lines: for no body will be luminous unless either the sun shine, or some other body supply its place, and direct the light in the same manner, *i. e.* in right lines.

Hence also arises *heat*. For all heat depends on fire; nor is it felt, unless increased in proportion to our senses, *i. e.* so as to be capable of affecting our organs.

While the sun is above the horizon, he impels all the rays, before vague and fluctuating, toward a *focus*; and such impulsions or determination is always in right lines: so that all our light, heat, and colour, is the effect of a rectilinear motion. Suppose, for instance, a fire, in a dark place, and a thermometer placed at a certain distance therefrom, with an iron-plate between them: In this case the thermometer will not be affected by the fire, by reason the rectilinear passage of the rays of heat is stop'd. Nor need it be added, that, under the like circumstances, no light, colour, &c. is perceivable: So that none of these act but in right lines.

If there were no sun, nor any body to supply its place, there would be no heat; *i. e.* the fire would not be determined in right lines: So that the

"great, dense, and fixed bodies, when
"heated beyond a certain degree, emit
"light so copiously, as by the emission
"and re-action thereof, and the reflections
"and refractions of the rays within
"the pores, to grow still hotter, till they
"arrive at such a period of heat as is
"that of the sun? Their parts may be
"further preserv'd from fuming away,
"not only by their fixity, but by the vast
"weight and density of the atmospheres
"incumbent on them, and strongly compressing
"them, and condensing the vapours
"and exhalations arising from them,

"Thus, we see that warm water, in an
"exhausted receiver, shall boil as vehemently
"as the hottest water, open to the air; the weight
"of the incumbent atmosphere, in this latter case, keeping
"down the vapours, and hindering the ebullition,
"till it has conceiv'd its utmost degree of heat. So, also, a mixture
"of tin and lead, put on a red-hot iron
"in *vacuo*, emits a fume and flame: but the same mixture
"in the open air, by reason of the incumbent atmosphere,
"does not emit the least sensible flame."

Ibid. Optic.

sun is the father of all heat; or some other body, that acts in the same manner as the sun: For the sun does not make heat, but only the difference between the heat of the day and night. The excess of heat which we feel by day, is not owing to the matter of the fire, but to the sun. For as to the quantity of fire, we have already observed, 'tis the same by night, as by day; and that 'tis the determination in parallel lines, that makes the difference in point of heat: Thus, nobody would imagine, upon stretching forth his hand, that it should be press'd as with a huge weight, both upward and downward, as if pinched in a press; and yet there is no dispute as to the fact: And the only reason why he is not sensible of it, is, that the pressure is equal every way. So it is with fire, which, when equally moved every way, does not give any sensible heat; but when the sun shines, he moves or directs it in right lines, and thus renders its heat perceivable*. It may be doubted, therefore, whether the sun, for all his spurs, be a hot body; since, if he were really so, he must transmit us more fire in winter than in summer †.

The sun's being a hot body doubted.

After the same manner arise colours, which are nothing else but the matter of fire driven in parallel lines; without which motion, there would no such thing ever be seen.

The intenseness of heat not increased in the same ratio as the quantity of fire.

If, now, the particles of fire, before moving in a parallel direction, become determined a-new, in lines that converge; the effect of the fire must, of necessity, be heighten'd; by reason, a larger quantity of fire is, by such means, collected into one place. And, were it not, that by such increase of quantity its particles have a greater attrition, the forces of fire would be proportional to the spaces it possessed. But in bringing the particles so near, 'tis impossible but they must strike on each other; and hence, the nearer they approach, the greater and quicker the attrition; and a brisk

* 'Tis not very difficult to conceive, how fire should become sensible either to the feeling, or sight, by being thus determined in right lines. By such determination, the vague, fluctuating corpuscles, are form'd into rays, and a train of them driven upon the organ in a constant succession. Hence, each subsequent one seconding the effort of the precedent one, the impression, by such a series of augmentations, at length is felt. Thus the air, wherewith we are every way surrounded, if left at liberty, is not perceiv'd; but if its particles be driven or directed in a stream, whether by a pair of bellows, or any other cause that excites a wind, the impression it makes will be very sensible.

† It has often been wonder'd why in *Nova Zembla*, the sun should never have power to melt the ice; notwithstanding, that, for the space of some weeks, his

brightness is not less conspicuous than with us. So the *Dutch*, who winter'd in that unhappy region, expected no less, than that in the month of *July* the sea should be thaw'd, and they left at liberty to pursue their voyage; but were mistaken. This gave my Lord *Bacon* occasion to observe, that the sun's direct rays have no sensible effect, not even on a level country; nor yet the reflected rays, unless the line of reflection be near that of incidence; i. e. unless the angle intercepted between them, be very small: so that they may, as it were, strengthen and increase the effect of each other. Now the more perpendicularly the rays fall, the smaller is this angle: Hence, in *Nova Zembla*, where they fall extremely obliquely, the rays, by reflection, are sever'd and dispersed, and their effect thus render'd insensible. *Bacon de Forma Calid.*

attri-

attrition, we shall hereafter shew, does collect fire of itself. If, then, the quantity of fire, in any place, be increased, *e. gr.* six-fold, the attrition will of consequence be augmented proportionably thereto. So that the force of fire does not only increase in the inverse ratio of the spaces, but also in the ratio of the increase of attrition.

Effect of the attrition of the particles of fire when near each other.

Beside, the very vicinity of the particles to one another, gives them new power; inasmuch as the force of attraction between them, is hereby increased. Thus, the load-stone and iron placed far asunder, have no effect on one another; but brought nearer, begin to act; and this the more strongly, as their distance is less. According to Sir *I. Newton's* experiments, these powers increase in the reciprocal ratio of the squares of the distances of the bodies; at least this law is found to obtain in electrical bodies. Hence, fire does not only act more strongly, as two particles thereof come to be collected into the same place where before there was but one; but as those two, being now united, attract each other more strongly, and act with united force. Tho' how much this additional force is, cannot be precisely determined; since we can only measure the relative quantity of fire, not the real or absolute one.

New power derived hence.

And hence appears the nature of *Dioptrics*, whose office is to explain the changes which the fire undergoes in passing thro' transparent bodies; and the laws wherein they are effected: as, that convex glasses, in refracting the rays of light, collect them into a point, call'd the *focus*: That concave glasses in refracting, disperse the rays, &c.

Business of dioptrics.

Hence, also, the foundation of *Catoptrics*, which teaches by what laws the rays of light striking on opake bodies, are reflected from the same. As, in concave mirrors, which reflecting the rays, make them converge into a *focus*; or convex ones, which disperse, or render them divergent. Several persons have attempted to find the quantity of light collected by a concave speculum: But the thing, to us, appears impracticable; by reason there is no body in nature that reflects in all its points, or that is without pores, which receive and absorb the light.

Of catoptrics.

Now, fire, determined by the sun, after the manner above-mentioned, toward the earth, does there acquire new powers, either in being acted on *catoptrically*; or, 2^o, *dioptrically*; or, 3^o, in undergoing a greater degree of attrition.

And hence arises another subordinate manner of collecting fire; for what was determined by the sun into parallel rays, might either be diffused again, or lock'd up and lost; which last is the case in black bodies, which are known to collect fire in greater quantity than others; as appears hence, that black clothes are found by the thermometer considerably hotter than white ones*: The reason hereof is, that the black suffocate, and absorb

Black bodies gather more fire than others.

Instanced in black clothes.

* This extraordinary susceptibility of heat in black bodies, Sir *I. Newton* accounts for hence, that the rays of light falling on them, are not either reflected from them, or transmitted thro' them; but, entering the bodies, undergo a great

number of reflections and refractions within, till their motion be spent, and, consequently, their heat, &c. lost; *i. e.* according to him, till they cease to be fire: but what motion and heat they themselves lose, the body receives.

A black soil.

such rays as fall upon them; whereas the white reflect them back again. And to the same cause it is owing, that black and white clothes being both dipt at the same time in cold water, and thus hung up to the sun, the black dries in a third or fourth part of the time required to dry the white: as is known to every dyer. So also a black soil is much hotter, *ceteris paribus*, than any other. This the peasants, who inhabit the morals *de Veenen*, where turf is dug, are very sensible of: Walking there but a little while, your feet shall grow extremely hot with the soil; but your face not at all: on the contrary, in a sandy place, the feet are scarce warm, when the face is scorch'd, by the great reflection.

Some maintain, that fire acts with the more force, as the resistance of the medium is less; but the contrary is true: for fire would be incapable of warming, unless either reflected, or collected. The heat would be never the greater for the sun's acting on the fire; unless, in its progress, it were either refracted or reflected, and by that means determined to one place more than another. And hence it is, that the cold, *ceteris paribus*, is always greatest in still weather; and that in the severity of winter, and particularly frosty weather, the heavens are clear. Thus, also, the tops of the tallest mountains, where the reflection and refraction are less considerable by reason of the want of clouds, are eternally cover'd with snow; as in *Peru*, *Mexico*†, the *Alps*, &c. And to the same cause it is owing, that the nights in *Armenia* are shivering cold.

Heat, then, depends not upon the fire's being sent or determined toward us, but on its being reflected, either by mountains, or clouds.

If fire be propagated thro' an uniform medium, it will never produce any considerable heat. And hence it is, that the degree of heat is not so very intense in the torrid zone, as one would otherwise expect; but that in the island of *Ormus*‡, 'tis perfectly scorching, and not endurable by any mortal, unless they were to screen themselves under water. The case is, that the said island is full of salt-rocks, which act like so many specula, and reflect the light in great abundance: so that the island, at a distance, appears like one continued fire.

Heat, therefore, does not immediately depend on the sun, but on bodies that reflect. Hence, in high places, and where the atmosphere is very rare, the heat is extremely feeble; and *vice versa*.

But it remains here to be observ'd, that, according as the direction of the sun's rays is greater, or less; the greater or less heat is produced. For,

† In the mountainous places of these countries, we are told, there is no such thing as pure water, but all ice. Plants make a shift to grow about the feet of the mountains; but higher up, no vegetable can live, not for want of food, but thro' the intenseness of the cold. Men, staying there but a little time, catch violent agues, which, with a little longer stay, grow incurable. *Boerhaave in MS.*

‡ The heat is here said to be so vehe-

ment, that people, like fishes, are forced to sleep in cisterns of water, with only the head out, which is kept suspended by a contrivance for the purpose. Another cause which some alledge for this excessive heat, is, that the island was antiently full of white mountains, which having in time been all laid level, the whole surface of the island is white, and thus disposed to reflect abundance of light. *Boerhaave in MS.*

1^o, A body striking perpendicularly on another, acts on it with all its force.

2^o, A body striking obliquely against another, acts with the less force, the more it deviates from the perpendicular.

Now fire, directed by the sun into right lines, must observe the same mechanical law as other bodies; and consequently its action must be measured by the sine of the angle of incidence. And hence fire striking on any obstacle, in a direction parallel thereto, has no sensible effect; by reason the proportion is almost infinite, *i. e.* nothing. Accordingly, Dr. Halley observes, that the sun radiating on the earth, in the morning, has but little effect; but, that when rais'd to the Meridian, he acts with all his force.

Now this is owing to the atmosphere, which being replete with an infinite number of corpuscles, reflects more of the sun's rays to the earth, when they fall perpendicularly, than would otherwise arrive there. For, whereas, falling obliquely, they would be reflected, and thus be thrown off, and dispersed into other parts: Now, that their incidence is perpendicular, they will pass directly thro'.

And hence arises what is frequently observed by the sailors, *viz.* that when the sun radiates obliquely upon the sea, as in the evening, there is no enduring his rays; by reason they are all reflected from the water, and scarce any lost therein: So that the rectitude, or obliquity of the rays, contribute very considerably to the collecting of fire. And this obliquity, &c. is to be consider'd in a twofold respect; both with respect to the matters in the atmosphere, and to the surface of the earth.

Now, heat may be varied two ways.

1^o, By means of the atmosphere: For this does not always remain the same. Thus, *e. gr.* water is naturally transparent; and if you warm it, it still retains its transparency: but if you make it boil, the vapour issuing from it, tho' perhaps a million times rarer than the primitive water, will not be transparent, but opake; by reason its parts are now in a different arrangement. And hence those legions of corpuscles every where floating in the vast receptacle of the atmosphere, whenever they acquire a different disposition, which they frequently do, alter the collection of the rays on the earth.

Add, that those white clouds which appear in summer-time, are as it were so many mirrors, and occasion excessive heat. These cloudy mirrors are sometimes round, sometimes concave, polygonous, &c. When the face of heaven is covered with such white clouds, the sun shining among them, must of necessity produce a vehement heat; since many of his rays, which would otherwise, perhaps, never touch our earth, are hereby reflected to us: Thus, if the sun be on one side, and the clouds on the opposite one; they will be perfect burning-glasses. And hence the phenomena of thunder, &c.

I have sometimes observed a kind of hollow clouds, full of hail and snow; during the continuance of which, the heat was extreme; since, by such condensation, they were enabled to reflect much more strongly. After

Thunder how
produced.

ter this came a sharp cold, and then the clouds discharged their hail in great quantity: To which succeeded a moderate warmth. Frozen, concave clouds, therefore, by their great reflections, produce a vigorous heat; and the same, when resolved, excessive cold. Hence, 'tis probable, that thunder is only produced, when such concave clouds, before convolved into spherical figures, are driven with opposite motions against each other; and the rays transmitted thro' those spheres, form burning foci. All clouds, 'tis probable, contain snow and ice; but these, in their fall thro' the warmer regions of the atmosphere nearer earth, liquify, and distill in drops.

The meteors in the atmosphere have likewise their share in reflecting of fire. These, in effect, are a sort of wandering fires, visible by night, and which determine the fire over and upon the earth.

Heat various
according to the
situation of the
earth.

2^o, It is varied by means of the earth: For, as the surface of the earth varies, so must the heat. Thus, sandy places reflecting more rays than others, must excite a greater degree of heat.

On the highest mountains, we always find the most cold, snow, and hail. In the sultry region of *Peru*, the mountains are all summer long covered with snow; by reason they only receive direct, and but little reflected fire; and the effect of fire arising merely from being determined by the sun into a parallelism, is found, by computation, to be very inconsiderable. For this effect, as already observed, is greater in winter than summer. Tho' the sun be in his apogee in summer, and his perigee in winter; yet will a night's ice bear his shining upon it five or six hours, e'er it be thawed. And if, as the sun rises nearer toward the zenith, the ice and snow at length begin to run; this is not owing to the greater force of the sun, but to the greater reflection, and collection of his rays from the circumstances and position of the atmosphere and earth. But the highest tops of hills are always free of snow: The reason whereof is, that water, *i. e.* the vapours and exhalations emitted therefrom, never rise by the sun's action above a mile high. But there are mountains a mile and a half high: To the tops of these, therefore, vapour, and consequently clouds, can never mount. And hence it is, that in very high mountains, as the *Pico de Theide* in *Bohemia*, tho' the middle part be eternally invested with ice and snow, and the bottom scorched with intolerable heat; yet, on the top, you find yourself in a pure, thin, serene air, and view the clouds hovering at a considerable distance below you. Hence, also, it is, that all thunder is confined within less than a mile's height. Add, that in caverns, and the hollow parts under ground, the heat is found very great: so that the air is coldest in the highest places, and hottest in the lowest; but in the intermediate atmosphere, very unequal.

Heat, therefore, depends on clouds, mountains, &c, which reflect the light variously; and on the direction of the sun's rays, or the position of his body with respect to us.

Hence, again, we gather that fire is the universal cause of all the motions about our earth: For, all fluidity depends on fire; and, accordingly,
in

in the large burning-glasses, the firmest bodies become fluid, and evaporate in fume: and the more fluid any body is, the more fire it contains*:

Whence

* Tho' fire be the great cause of fluidity, and motion; yet is it frequently found in such small quantity, that, instead of fusing, or keeping them in a state of fusion, it becomes inclosed, and fixed therein, so as to remain, as it were, imprisoned, till some external cause come to its assistance, and open the cells which before retain'd it.

This is the case in quick lime, as also in lead, tin, regulus of antimony, &c. when calcined: In which the younger Lemery observes two things: 1^o, That the fire thus inclosed, makes a sensible addition to the weight of the body; amounting sometimes to one tenth of the whole: And, 2^o, That during this imprisonment it still retains all the particular properties or characters of fire; as appears hence, that when once set at liberty again, it has all the effects of other fire. Thus, a stony or saline body being calcined, and water poured on them; that fluid is found sufficient, by its external impression, to break up the cells, and let the fire out: and upon this the water is render'd more or less warm, according to the quantity of fire lodg'd therein. Hence, also, it is, that as some of these bodies contain a deal of fire; and the slightest occasion is capable of disengaging it: upon applying them to the skin, they burn, and raise an eschar not unlike that of a live coal.

To this it is objected, that the particles of fire are only such in virtue of the rapid motion wherewith they are agitated: So that to suppose them fixed in the pores of a body, is to divest them at once of that which constituted them fire; and, consequently, to disqualify them for producing the effects ascribed to them. To which M. Lemery answers, that tho' the rapid motion of fire do contribute very greatly to its effects; yet, the particular figure of its particles is to be consider'd withal. And tho' fire should be detain'd, and fixed in the substance of bodies; yet why should it fare worse than other fluids in the same circumstances? Water, for instance, is a fluid, whose flu-

idity depends, as already observed, on fire; and, consequently, is less fluid than fire: And yet, every day, water is inclosed in bodies of all sorts, without losing its fluidity, or any of the properties that characterize it. Add, that when water is froze, the motion of its parts is, doubtless, discontinued; and yet the figure of the particles remaining the same, it is ready to commence a fluid, as before, upon the least warmth. Lastly, tho' salt be allow'd to be the matter of tastes, and that it has certain properties, arising chiefly from the figure of its parts; yet, it only acts when dissolved; or, which amounts to the same, when it swims in a fluid proper to keep its parts in motion: yet is it not less salt, or less the matter of taste, when not in a state of dissolution. To despoil it of that quality, the figure of its parts must be alter'd.

As to what may be further objected of the impossibility of fixing so fine, subtle, penetrative, and active a matter as fire, within the spongy substance of a gross, porous body; it will be of no great weight, unless it can be proved, that the pores of the cells are bigger than the same. If it be insisted, again, that a body which could find its way into a solid body, might get out again the same way; and that as it only penetrated the body, inasmuch as its own corpuscles were smaller than the pores; so, the same pores must let it out again: It is answer'd, that the pores are not now in the same condition as before; the fire, in calcining, open'd, and dilated the pores; which, upon the fire's ceasing, must close; and contract again. *Mem. de l'Acad. An. 1713.*

"Tho' a great likeness might be expected," says Mr. Boyle, "between the particles of fire adhering to quick lime, and those of highly rectified spirit of wine; yet I have not found, that the affusion of that spirit upon quick lime produced any sensible heat, or visible dissolution of the lime, tho' it seem'd to be greedily suck'd in, as common water would have been. And I further tried, that

Whence it is, that water, deprived of all its fire, fixes into ice; and when exposed afresh to the fire, resolves into water: and all fluids whatever, if destitute of fire, would do the same. Nor is it any objection that spirit of wine, and oil of turpentine, do not freeze in the severest winter; for this is owing to the feebleness of the cold in our climate: And, tho' they do not absolutely congeal, yet we find them condense into at least three fourths of their former space. The truth is, there is no such thing in all nature as absolute cold; the most severe we have ever known, was three years ago; when the water would freeze while it run down my hand: and yet even then, the cold was not so compleat, but that I could make an artificial cold greater by twelve degrees. Air, the less warm, the denser it is; and, 'tis more than probable, that, were it perfectly clear'd of all fire, it would become absolutely rigid.

The cause, therefore, why bodies do not cohere more firmly than they do, is the action of the fire: And hence, it is fire alone that gives bodies their motion; consequently, the cause of all mutation in bodies, depends on the same fire, which is never at rest, but always acts the more forcibly on bodies, as they are the more solid, *i. e.* as they make the greater resistance to it: Whence it is, that gold admits a much greater degree of heat than other bodies. And thus, all rarefactions, maturations, vegetations, distil-

"that if cold water were poured on the
"same lime, so drenched, there ensued
"no manifest heat; nor did the lump ap-
"pear swell'd or broken, till some hours
"after; which seems to argue, that the
"texture of the lime admitted some par-
"ticles of the spirit of wine into some of
"its pores, which were either larger, or
"more fit, without admitting it into the
"most numerous, whereinto the liquor
"must be received, to be able suddenly
"to dissipate the corpuscles of lime into
"their minuter particles." *Boyle Mech.*
Orig. of Heat, &c.

"These phenomena seem to shew, that
"the disposition which lime has to grow
"hot with water, greatly depends on
"some peculiar texture; since the a-
"queous parts, which one would think
"capable of quenching most of the fiery
"atoms supposed to adhere to quick lime,
"did not near so much weaken the dis-
"position of it to heat, as that access of
"the spirituous corpuscles, and their con-
"texture with those of the lime, in-
"creased it." *Boyle Mech. Orig. of Heat,*
&c.

"If, instead of cold water, you quench
"the lime with hot water, the ebullition
"will be, oftentimes, far greater than if the

"liquor were cold. And this might well
"be expected, hot water being much
"fitter than cold, suddenly to pervade
"the body of the lime, and hastily dis-
"solve, and set at liberty the fiery and
"saline parts, wherewith it abounds. And
"what a greater interest salts may have
"in producing such heats than cold, I
"have also tried, by pouring acid spirits,
"and, particularly, spirit of salt, upon
"good quick lime. For by this means
"there would be a far greater degree of
"heat excited, than if I had used common
"water; and this, whether I employ'd
"the spirit cold or hot." *Boyle Hist. of*
Cold.

"It is not easy," says the same author,
"to apprehend how such light and mi-
"nute bodies, should be so long detained,
"as must by this hypothesis be allowed,
"in quick lime especially; since no great
"heat ensues the pouring of water upon
"minium, or *crocus martis per se*, tho' they
"have been calcined by a violent fire,
"the effluvia whereof seem to adhere to
"them, by the increase of weight the
"lead and iron manifestly receive from
"the operation of it." *Boyle Mech. Orig. of*
Heat.

lations, fermentations, effervescencies, &c. are perform'd by this fire, in subterranean places*.

Second way of collecting fire.

THIS is by *attrition*, and does not consist in directing the fire into parallel lines, but merely in collecting it. Now, attrition or friction is a swift motion of two bodies, whose surfaces are applied against each other; the swiftness being such, in the present case, as that nothing but fire can follow, or keep pace with it. *Attrition collects fire.*

For the motion of a body, we observe, may be so far accelerated, as that air cannot succeed fast enough into the places continually relinquished thereby: And hence fire, the swiftest body in nature, immediately slips into the place, and by this means becomes collected in the path of the moving body. So that the moveable has, as it were, a fiery atmosphere around it. *And how.*

So, the axes of wheels of carriages, swiftly driven, or heavily loaden; mill-stones, when rapidly turn'd by a too violent wind, or stream of water; iron held against the grind-stone; and ropes of ships, &c. vehemently pressed against their pulleys, conceive heat, and frequently break out into flame. And the harder and more elastic the bodies are, the greater the force wherewith they are press'd against each other, the larger their surface, and the swifter they are moved; the more fire will they collect. Thus steel, *ceteris paribus*, strikes fire faster than iron; and a diamond, by friction, conceives heat the soonest of all bodies: So gold retains heat the longest, &c. *And in what law.*

Thus, the *Indians*, who don't know the use of the flint and steel, have an extraordinary kind of wood call'd *Sideroxylis*, which, when briskly rubb'd on another piece of the same, yields sparks both more readily, and plentifully than our flint, &c. †.

Now

* Historians relate, that the sun, for a whole year together, appear'd pale, and obscure; his face being cover'd over with dark spots; so that his lustre scarce exceeded that of the moon. The effect hereof was, not a very extreme cold, but a general languishment and destruction of all things. And yet there was not less fire in our atmosphere than at other times; but only that fire wanted the necessary direction. *Boerhaave Cod. Impres.*

† A large glass-tube rubb'd on a linen or woollen-cloth, will emit light in the dark; and the tube thus heated, acquires a sensible electricity. *s' Gravesande Element. Phys. Math.*

A globe of glass eight or ten inches in diameter, being put in a frame where it may be swiftly turn'd about its axis; will, in turning, shine, where it rubs against the palm of the hand applied to it: And if, at the same time, a piece of white paper, or white cloth, or the end of one's finger be held at the distance of about a quarter of an inch from that part of the glass where it is most in motion; the electric vapour excited by the friction of the glass against the hand, in striking against the paper, cloth, or finger, will be put into such agitation, as to emit light, and make the white paper, cloth, or finger, appear lucid like a glow-worm;

Now this attrition may happen either in the air or the earth, infinite ways; and hence arise those sudden flushing heats we sometimes feel: Thus, oil, vitriol, and water, mix'd, make a vehement attrition, the effect whereof is an intense heat. But instances of such bodies are almost infinite.

Both these kinds of fires, both that excited by the sun, and that by attrition, the chemist is to make use of; and direct them to his own ends, viz. the performing of operations.

Nature of fire.

We shall now endeavour to explain the nature of fire; but, if by nature you understand the thing itself, in that sense we do not know the nature of any one body; and he must be arrogant, and vain, that imagines he does. No man will ever arrive to know what a grain of sand is; for God has made every thing he created, infinite: Accordingly, there is no one body, how small soever, but contains in it every thing that is contained in the whole universe: Thus, the least line may be divided into infinite parts; and hence all magnitudes are only consider'd comparatively.

So, when I say, I here intend to explain the nature of fire; I mean, the manner wherein it acts; which is enough in conscience, tho' we do not know by what it acts: Thus no man could ever give a reason why a body striking on another, should lose of its own motion in proportion to its bulk; yet the mathematicians contentedly take the effect, and make use of it in the demonstrating of many other matters.

Fire a body extended, impenetrable, moveable.

1^o, The first thing we affirm concerning fire, is, that it is corporeal, i.e. consists of an infinite number of corpuscles, or little bodies.

By body, *corpus*, we mean any thing extended, impenetrable, moveable, figurable, &c. Now, that fire is *extended*, nobody doubts; that it is *impenetrable*, is evident hence, that it excludes all other body out of the space itself possesses, and is excluded by them; and that it is *moveable*, will easily

and in rushing out of the glass, will sometimes push against the finger, so as to be felt. *Newton ubi sup.*

We must add, however, that the globe is to be first exhausted of air; in which case, both the inner and outer surface will appear all luminous: If it be not exhausted, there will no light be seen in the body itself, but on bodies at a small distance from it.

Hence, and from some other experiments of the like kind, *s'Gravesande* infers, that the glass has a kind of atmosphere in and about its surface, which is excited, and put into a vibratory motion by the friction; by which motion the fire contain'd in the glass is expel'd; and that this atmosphere, and fire, are more easily put in motion, and discover themselves more readily, upon the absence of the air. *Ibid.*

Mr. Boyle furnishes various instances of the effect of friction in the production of heat: "Having caused a piece of iron to be turn'd, and placing my naked hand, at a convenient distance, to receive the little fragments, as they flew off from the rod; they were so intensely heated, by the quick action of the tool upon them, that they seem'd almost like so many sparks of fire. And an expert workman in brass assured me, that the heat in the little fragments thrown off, when he turn'd that metal, were sometimes very offensive to his eyes; and that, when he employed a rough tool, which took off greater chips, he had found the heat so vehement, as not only to scorch his eye-lids, but the hard skin of his hand." *Boyle, Effects of Languid Motion.*

be granted, since 'tis it gives motion to all things; and this by means of its own impenetrable resistance. Thus, if you take a slender iron-needle, and sustain it on the point of a pivot, and thus oppose one end of it to the *focus* of a large burning-glass; it will immediately be driven round: So that fire acts on, and moves bodies, by virtue of its own impenetrable resistance. *Fire made to drive a body round.*

Again, fire, we have said, *expands* the air; and in order to that expansion, it must give it motion; expansion itself being no other than a certain motion: but nothing can move a resisting body, such as is the air, out of one place to another, unless itself be a body in motion, and impenetrable by air. And the more solid a body is, and the greater resistance it makes, the more does the fire act thereon. And hence it is, that gold admits of the greatest heat of all bodies.

But what incontestably evinces the corpuscles of fire, is the following experiment: Take a quantity of the purest mercury, put it in a glass-vial with a long neck; and thus keep it, the space of a year in a gentle heat, not much greater than that of a healthy man; and it will be then found reduced into a solid mass, with a considerable augmentation of its former weight, from the particles of fire receiv'd, and lodg'd therein. Add, that there are divers other bodies, whose weight the fire increases in calcining them. Thus, antimony, being exposed in the *focus* of a small burning-glass, emits a continual fume; so that one would imagine it would all exhale: and yet, upon taking it out again, it is found to have gain'd in weight*. *Fixes and incorporates with several bodies.*

Farther,

* Mr. Boyle gives us several experiments to shew, " that fire and flame may incorporate with solid bodies, and increase their weight. Having disposed a quantity of sulphur, and a copper-plate, in a tall receiver, so, as that the plate was at a considerable distance from the sulphur; upon firing the sulphur, and letting it burn away, so as its flame reach'd the metal, the flame seem'd to have actually penetrated it, and to have made it visibly swell, and grow thicker; which appear'd to be done by a real accession of substance; since, after he had wiped off some little adhering sordes, and, with them, several particles of copper, that stuck close to them, the plate was found to weigh near thirty-two grains more than at first; and, consequently, had increased its former weight above a fifth part. *Ponderab. of Fire and Flame.*" Upon a very shallow crucible, we put one ounce of copper-plate, and

" set it in a cupelling furnace, where it was kept for two hours; and then being taken out, we weighed the copper, which had not been melted, (having first blown off all the ashes) and found it had gained thirty grains. Boyle, *ibid.*

" Steel being a metal that, as experience informed me, will very easily be wrought on by fluids of a saline nature, 'twas reasonable to expect, that flame would have a greater operation on it, especially if it were beforehand reduced to small parts, than on any bodies hitherto described. And, accordingly, four drams of the filings of steel, being kept two hours on a cupel, under a muffler, acquired one dram, $6\frac{1}{4}$ grains, increase of weight.

" A piece of refined silver being put upon a cupel under a muffler, and kept there for one hour and an half, was taken out, and weigh'd again; and as before it weigh'd three drams, $32\frac{1}{2}$ grains,

Farther, fire moves successively *, and changes all bodies ; which cannot be effected without contact.

Its motion may be stop'd, and that in any point of its progress ; consequently, it may be contain'd in a certain place.

“ grains, it now weigh'd, in the same
“ scales, 3 drams, $34\frac{1}{2}$ grains. *Id. ibid.*

“ And to prevent all suspicion of any
“ increase of weight in the metal, arising
“ from smoke, or saline particles, getting
“ in at the mouth of the vessel ; I made
“ the experiment in glasses, hermetically
“ seal'd, as follows : In eight ounces of good
“ tin, carefully weighed, we hermetically
“ seal'd up in some tin, which had been,
“ before, partly calcined in a glass ; being
“ melted again in a crucible, we weigh'd
“ out just eight ounces ; and these we
“ put in a bolt-head of white glass, with
“ a neck above twenty inches long, which
“ being hermetically seal'd, after the
“ glass had been a while kept over the
“ fire, lest it should break by the rare-
“ faction of the air, the metal was kept
“ in fusion for one hour and a quarter.
“ Being unwilling to venture the glass any
“ longer, it was taken from the fire, and
“ when it grew cold, the seal'd end was
“ broken off ; but before I could have the
“ bottom cut out, I observ'd, that the
“ upper surface of the metal was very
“ darkly coloured, and very irregularly
“ rough ; and the lower part had between
“ the bottom, and the under-side of the
“ lump, a pretty deal of loose dark-co-
“ lour'd calx ; tho' the neighbouring sur-
“ face, and some places of the lump it-
“ self, look'd by candle-light of a golden-
“ colour. The lump, and the calx toge-
“ ther, were weigh'd in the same scales
“ carefully, when we found the weight
“ to have increased above twenty-three
“ grains ; tho' all the calx we could easily
“ separate, being weigh'd by itself, a-
“ mounted to near eighty grains. *Boyle*
Ponderab. of Fire and Flame.

“ We received this further information
“ from our experiments, that bodies very
“ spirituous, fugitive, and minute, may,
“ by being associated with proper par-
“ ticles, tho' of quite another nature, so
“ change their former qualities, as to be
“ arrested by a solid and ponderous body
“ to that degree, as not to be driven a-

“ way from it by a fire intense enough
“ to melt, and calcine metals. For the
“ foregoing trials seem plainly to disco-
“ ver, that even the agitated parts of
“ flame, minute enough to pass thro' the
“ pores of glass itself, were, some way,
“ entangled among the metalline particles
“ of tin and lead ; and thereby brought
“ to be so fixed, as to endure the heat
“ that keeps those metals in fusion, and
“ gradually reduce them to calces ; a pha-
“ nomenon that one would not easily look
“ for, especially considering how simple
“ a texture that of lead or tin may be,
“ in comparison of the more elaborate
“ structures of many other bodies.

“ And this phenomenon, which shews
“ us what light, and fugitive particles of
“ matter may permanently concur to the
“ composition of ponderous, and fixed bo-
“ dies, will, perhaps, afford useful hints
“ to the speculative ; especially, if this
“ strict combination of a spirituous and
“ fugitive substance with such as being
“ gross and unwieldy, are less fit than
“ organized matter, to entangle or detain
“ them, be apply'd, as it may be, with
“ advantage, to those aggregates of spiri-
“ tuous corpuscles, and organical parts,
“ that make up the bodies of plants and
“ animals. And this hint may suggest a
“ considerable inference to be drawn
“ from the operation of the sun-beams on
“ appropriated subjects ; supposing it to
“ prove like that flame of tin and lead.”

Boyle Ponderab. of Fire and Flame.

* It has been proved, that fire moves
from one place to another ; and, that such
a motion is not successive, should seem
to imply a contradiction. We actually
observe fire to fly off in vapours, and
smoke ; the fire, in such cases, carrying
with it the volatile parts of the body it
adhered to : The motion of the fire is
certainly immensely retarded by this ac-
cession of other matter ; and yet, under
all this disadvantage, its velocity is very
great. *s' Gravesande, ibid.*

The same fire before dispersed, may be collected into a certain place ; and when collected, may be dispersed again.

Fire, again, is alter'd in its progress, according to the different bodies and obstacles it meets withal. For it is equally, and uniformly impel'd by the sun ; but falling on certain bodies, it is collected into focus's : so that its motion is alter'd according to the bodies that happen in its way.

Add, that it is refracted, and reflected, and observes all the stated laws of refraction and reflection which obtain in other bodies.

Since, then, fire has all the properties of body, we may safely conclude it to be body.

2^o, The corpuscles or molecules whereof fire consists, are the *smallest* of The minutest and subtlest of all bodies. all others ; we mean, of all those we know of. This is easily evinced, inasmuch as it penetrates all known bodies, and there is none that denies it access ; for it passes even thro' gold, the most solid of all bodies. We can exclude water, oil, spirit, and all other fluids out of a body ; but fire alone will escape, in spite of all our precaution.

If a fine silver wire be drawn, and cover'd over with the purest and Penetrates all bodies. closest gold, wherein the best microscope cannot discover the least pore ; neither will the particles of fire pass thro' the same, not even if it be applied to the aperture of a *camera obscura*. And yet if you put a mass of the most solid and purest gold in cold water, and leave it there till sufficiently cool'd, and then taking it out, expose it to the open air ; you will find it soon return to a degree of heat, equal to that of the medium ; as will appear by the thermometer : Now, to return to the heat of the medium, is to receive or imbibe so much fire. Add, that in the *Grand Duke of Tuscany's* court was a hollow golden ball made, and fill'd with water ; which being exposed to the rays of the sun, the water was soon heated thereby. And even gold. After the like manner, a solid ball of gold being put in boiling water, the heat will penetrate to the very centre thereof ; so that if you presently cleave it into two hemispheres, and apply them to the thermometer, the spirit will rise apace. Gold, then, occasionally takes in or lets out a quantity of fire proportionable to what is contain'd in the same space in the medium it is found in : So that there needs no further proof of fire's penetrating the most solid bodies ; nay, of its passing thro' them with the same ease and freedom as thro' air. And hence it is, that there is the same quantity of fire contain'd in all bodies.

Again, we are taught by *dioptrics*, that the smallest aperture or pore imaginable, will receive innumerable rays of fire at the same time, and all perfectly distinct, and without the least confusion among themselves. An infinite number of its rays will pass thro' the smallest hole.

Thus, take a plate of lead, make a perforation therein with the finest needle, and place it before a window, at which no light can enter ; as in a *camera obscura* ; then, fixing a piece of paper on the wall opposite to the perforation : you will have a perfect and elegant representation of all the external objects, as mountains, trees, houses, rivers, &c. upon the paper. And as every thing is here represented perfectly distinct, 'tis evident the rays pass'd thro' the aperture without blending at all. Since, then, those rays

rays are so exceedingly fine, that the rays of a whole hemisphere shall pass freely, without mixing, thro' a pin-hole ; and light is nothing but fire : it follows, that the parts of fire are so minute, that they may pass without any opposition, or loss of force, thro' all the bodies in nature.

Fire the most solid of all bodies.

3^o, Fire is the most *solid* of all bodies, *i. e.* consists of the most solid particles ; or, its elements the most immutable, as not admitting of being separated into any lesser corpuscles. Solidity depends on a firm cohesion of the parts of a body : And hence, where the pores are fewest, and consequently the substance most, there the solidity is greatest. There must be very few pores, therefore, and those the smallest imaginable, in a body so exceedingly minute as fire ; and those there are, must be impervious to all other bodies, since we have already made appear, that fire itself is the smallest of all other bodies. Now, the larger a body is, and the more particles it consists of, the more pores it must contain : Thus, two bodies being join'd to each other, can neither constitute the smallest, nor the solidest body, by reason there will always be pores left in the juncture. And hence, a pound of gold must have more pores, and consequently be much less solid than the ten thousandth part of that quantity. So that the corpuscles of fire, in being the minutest of all bodies, must likewise be the most solid.

And whence.

The smoothest and most polish'd of bodies.

4^o, The fourth property of fire, is, that it is the most *polite* and smooth of all bodies ; for thus we denominate a body which is perfectly equable and similar in every part : *e. gr.* which appears every where figured alike, and has no roughnesses or eminences. And such a body is fire ; for had it eminences, they must be less than fire itself ; and, consequently, fire might be still made lesser ; nay, and of course, by the continual action and attrition of the fiery corpuscles on each other, must be continually so : which implies a contradiction ; it having already been granted, there is no body smaller than fire.

We have likewise shewn, that fire is the most solid of bodies ; which it could not be, if it had asperities ; for then it must consist of several parts, and consequently admit of pores.

But it is allow'd, that slipperiness depends on politure ; and that fire is the most slippery of bodies, is evident from its particles moving in straight lines, and in that they undergo no change by reflection, nor are any way intangled, but always pass freely and alike thro' the most solid body. Whereas, were they rough, and scabrous, they must necessarily hinder each other's motion. Add, that if a ray thus transmitted thro' a little aperture, be examined ; it will be found to answer the just laws of refraction and reflection ; *i. e.* it makes its angles of incidence equal to the angles of reflection, and *vice versa* : which it could not do, were it not extremely spherical and smooth : For, in all the doctrine of optics, catoptrics, and dioptrics, the refracted and reflected bodies there consider'd, are supposed to be perfectly spherical.

The simplest and most similar of all bodies.

5^o, Fire is the most *simple* of all known bodies, and consequently the most immutable.

By

By *simple* body we mean that which is the same in all and every its parts, as in the whole; or a body equally homogeneous in every part. Now, the simplicity of fire consists, first, in this, that it has but few or small pores; for, so far as it admitted of void and corporeal parts, it would be compound and heterogeneous: And, secondly, in the minuteness of its parts; for the bigger a body is, the more compound it must be.

Fire, therefore, must be admitted in the quality of the most simple of bodies; and especially as it remains immutable, and always operates after the same manner.

Yet, what appears very strange, fire itself, thus minute, solid, polite, and unchangeable, is not perfectly simple; and there are no less than three ^{Differences of fire.} diversities discover'd therein.

1^o, First diversity is in point of colour. The great Sir *I. Newton* has shewn, that one single white ray of light, which all men imagined perfectly simple, and uncompounded, does really consist of seven other different rays; which, when united together, constitute a beautiful white; but when separated, appear to be violet, green, blue, orange, yellow, and red*.

Fire, therefore, which affords a white colour, is an assemblage of seven kinds of fire, of so many different colours. And who will affirm, that each, even of these *radioli*, does not consist of as many more? Indeed, thro' the weakness of our sight, 'tis possible we may never arrive to perceive them; so that our way, here, must be to take each of the seven as the most simple of all bodies; in respect, we mean, of our senses. 'Tis but forty years ago, that a ray of light was held indivisible; and now we can divide, and separate it into seven other distinct rays; in the same manner, as if these seven fingers now closed into one group, were separated into seven parts. Nor can it be assured, that each of these seven elemental rays is not, in like manner, composed of seven other lesser threads.

2^o, Another diversity of fire lies in this, that each corpuscle has sides ^{Its sides have different powers.} differently affected, and which have different properties: And, which must be allow'd no small degree of subtlety, we can take one single corpuscle hereof; e. gr. a yellow or blue one, and apply its surface in such manner to a reflecting or refracting body, that, with all its simplicity, it shall shew a difference in its sides.

This Sir *I. Newton* first shew'd in *Iceland* crystal; which is found to attract ^{Iceland crystal.} a corpuscle of fire, if one of its sides be turn'd toward the crystal; and repel it, if the other be: or, while one and the same ray, e. gr. a blue one, is passing, one part of it is attracted while the other is repel'd †.

3^o, The

* Every sort of ray, as it is more or less inflected by refraction, has a particular colour. The rays, e. gr. least bent by refraction, are red; those next, orange; then yellow, green, blue, purple and violet; which last are the most refran-

gible. And such colour of any ray is absolutely unchangeable by any refractions, reflections, separations, mixtions, &c.

† *Iceland* crystal is a transparent, fissile stone, of the nature of a talc: a piece hereof being laid on a book, every letter seen

Particles of fire
differently re-
frangible and
reflexible.

3^o, The third diversity is the different refrangibility and reflexivity of the different parts of light. This arises hence, that the parts are endued with a different attractive power; and, accordingly, attract, and are attracted by other bodies differently. Thus, a white ray, either passing thro' a body, or being reflected from it, its several component rays, *e. gr.* the red and blue, are differently attracted by the body; *i. e.* the blue more, the red less; and thus become differently refrangible, and reflexible: and by that means easily separable from each other ||.

But

seen thro' it, will appear double; by means of a double refraction which it makes of the visual rays in passing thro' it: And a ray of light falling on its surface, in any direction, becomes divided into two rays, from the same cause. Now, one of these refractions is perform'd, according to the usual rule of optics; *i. e.* the sine of incidence out of air into the crystal, is to the sine of refraction as five to three: But the other, call'd the unusual refraction, observes another rule; and the ray, which by the first surface of the crystal, was refracted after the usual manner, upon passing the second surface, is also refracted: so that both emerge out of the second surface parallel to the incident beam: And the same will hold, if the rays pass thro' several pieces of *Island* crystal placed parallel to each other; the ray refracted after the unusual manner in the first surface of the first, being found to persist in the same way, in all the surfaces of all the rest.

Hence Sir *I. Newton* gathers, that there is an original difference in the rays of light, by means of which, some are constantly disposed to be refracted after the usual, and some after the unusual manner; for if the difference were not original, but arose from some new modification which the rays underwent at their first refraction, it would be alter'd by new modifications in the following refractions. And this may give us a suspicion of more original properties in light, than have yet been discover'd.

In effect, the rays of light appear to have several sides, endued with several original properties; for the two rays, thus differently circumstanced, are not of different natures, so, as that one in all positions of the crystal will be refracted after the one; and the other, after the o-

ther manner: all the difference between them consists in the different position of the sides of the ray to the planes of perpendicular refraction: And the same ray, in this or that position of its sides to the crystal, will be refracted either in the usual or the unusual manner. *Newton, Optic.*

|| The reflection of the rays, Sir *I. Newton* shews, does not arise from their striking on the solid, impervious particles of bodies: such reflected rays, tho' they approach infinitely near the body, never touch it; for all those which do touch, are lost and extinguished in the body. The power by which the particles are reflected, is not the immediate resistance of any particles struck upon; but a power equably diffused throughout the whole surface of the body, whereby it acts on light, either attracting or repelling it without contact: which power is the same with that whereby, in other circumstances, the rays are refracted; and by which, also, they are first emitted from the luminous body.

And hence it is, that where light passes without refraction, there it also passes without reflection; that where the refraction is strongest, there the reflection is so likewise; that light, passing out of a denser into a rarer medium, is more copiously reflected, than in passing from a rarer into a denser; and the reflection is the greater, as the difference of density in the mediums, is greater. Add, that every ray of light, in its passage thro' any refracting surface, is observ'd to be put into a certain transient state, which returns at equal intervals, whereby it is disposed to be now easily refracted, and then easily reflected. These alternate fits of easy reflection, and easy transmission, Sir *Isaac* accounts for, from the

But for Sir *I. Newton*, who first discover'd all these diversities in fire, which plainly argue it a compound body, we should have taken it for a perfectly simple one. But God has laid up infinites, even in the *minima natura*.

6°, Fire moves with the greatest velocity of all bodies.

Fire the swiftest of all bodies.

The antients all maintain'd, that light moved instantaneously; which opinion is countenanced by many observations of the eclipses of the sun and moon.

But *O. Roemer* has endeavoured, from the eclipses of *Jupiter's* satellites, to shew, that it moves successively, or in time; and that it employs eight * seconds in travelling from the sun to the earth. Whence it should follow, that the velocity of light exceeds that of a cannon-ball by 1314000 times.

How much it exceeds that of a cannon-ball

But *Cassini* and *Maraldi* contest *Roemer's* observation; it seems, that what he had observed in one satellite, does not appear in the rest. So that this point must be left to further discussion. In the mean time, what pleads strongly for the successive motion, is the following experiment: Take a vessel full of cold water; and apply several thermometers at several distances from the same: and you will find the heat diffuse itself in concentric waves, arriving at those nearest it, first; and at the rest in the order of their distance.

Sir *I. Newton* has even shewn, that light moves with greater velocity thro' dense bodies, than thro' a *vacuum*.

From the whole, it appears, that the motion of fire is the first, and most universal of all motions: That this fire needs no *pabulum* to sustain it; that it cannot either be created, or destroy'd, or produced: but, as 'tis impossible that fire should ever not be fire; so likewise 'tis impossible, that what is not fire, ever should be fire: And that the greatest augmentations of fire are made by reflecting it, and bringing it nearer together. Thus, suppose a concave body, *e. gr.* a mirror, consisting of any number of other concaves; exposed to the sun: The rays falling hereon, will be reflected at equal angles, and thus tend, converging toward a point where the fire will be most intense.

After the like manner, if a wall be hollow'd in a circle, or a segment thereof, and thus lined with plaster, no body will be able to endure the heat it will project, when turn'd toward the sun. *Mirrors made in walls.*

In *Saxony* there are burning mirrors made of wood turn'd spherically, of wood. lined with plaster, and gilt over with leaf-gold; which have incredible effects: Nay, we are told of a peasant that made a very powerful one of *Of straw.*

vibrations of a fine, subtle, ethereal, elastic medium; vastly finer, and more elastic than air, which penetrates thro' all bodies, and is diffused thro' all space. The rays of light, by their attractive powers, or some other force, excite vibrations in this medium; which vibrations being swifter than the rays, over-

take them successively, and agitate them so as by turns to increase and decrease their velocities, and thereby put them into those fits.

* "Light moves from the sun to us, the distance of about 70000000 English miles, in about seven or eight minutes of time." *Newton. ubi supra.*

straw, by applying the polish'd sides of the straw, so as to form a segment of a sphere. The fire reflected from this stramineous surface, would readily melt most metals; yet, itself, all the while remain cold and unhurt.

This is what we know of the nature of pure or elementary fire; *i. e.* these are the characters or properties of its action; which is the only knowledge the subject will afford us. And fire, with all these six characters or properties, may be collected in all places of the earth, and made obvious by its effects to our senses: that, *e. gr.* found in the frigid zones, is justly the same as that near the equator: So, on the top of the pike of *Teneriff*, where the air is so very rare, that, like the *vacuum* of an air-pump, it scarce suffices to preserve fire, and prevent its dissipating and disappearing; yet, the fire collected even here, tho' it scarce burn at all, has all the characters above enumerated.

We now proceed to vulgar fire.

Vulgar or common fire.

Vulgar fire.

BESIDE elementary fire, hitherto discoursed of, there is another call'd vulgar or common fire: but this, in reality, is the same with the former, only under some difference of circumstances.

Collected by attrition.

It is collected, 1^o, By attrition: Thus, when two bodies are violently rubb'd against each other, a real fire is excited: And thus, a steel and flint struck against each other, even in winter, they will grow hot to such a degree, as to give fire to sulphur.

Putrefaction of vegetables.

2^o, By the putrefying of vegetables, of what kind soever they be: Thus, throwing water on hay, and then pressing it close down, with a board over it, it soon ferments, grows warm, emits smoke, and at length breaks into flame. But this method depends on the air, which being here compressed, raises an attrition by the power wherewith it endeavours to expand, or set itself at liberty. And the same holds of all herbs.

Vulgar fire of the same nature with elementary.

The fire thus produced, or rather thus collected, is pure fire, and discovers itself by all its effects, perfectly alike, and equal to, the elementary fire; only that it does not reside in so pure a substance. Thus, that gather'd from horses dung, moisten'd with water, and closely pressed, is found in all respects the same with that of a burning-glass; yet this dung is nothing but hay broke into very little pieces or shreds, and deprived of its juices. And the reason why the dung of other animals will not do the same, is, that horses excrements are retain'd a considerable time in the little *sacculi* of the intestines, while all the humidity may be express'd. So that even a horse's dung, when under a *Diarrhaea*, will not have the effect*.

* My Lord Bacon, indeed, suggests, that the fire produced by any putrefied thing, is very different from solar Fire. But this is a deception: for that produced by the dung of an animal, if it be receiv'd in a vessel hermetically seal'd, is found to

have the very same effect on the vessel, and the matters therein contain'd, as the same degree of the sun's fire. The dung, *e. gr.* of a horse, being laid by itself for some time, grows incredibly hot. *Baave Cod. Impres.*

3^o, The

3°, The third way of collecting this fire, is by the admixture of chemical liquors: As when two liquors, which in themselves are cold, being mixed together, raise an effervescence, and at length a vehement heat †. By such means, a fire is sometimes produced beyond any thing the thermometer can measure.

Thus, spirit of nitre, and oil of cloves, suddenly mix'd, raise a fire nothing inferior to that collected by M. Vilette's mirrour: or, in lieu of oil of cloves, any other oil, heavier than water, may be used: But such experiments are not made without great danger. This method of collecting fire was first discover'd by Ol. Borrichius.

4°, Fire is collected by the contiguity of air to certain bodies: e. gr. to phosphorus, which is a substance procurable from the putrefied parts of all animals and vegetables. For, after extracting the water, oil, and salt from the same, if you continue to urge them with a vehement fire, you will have a blueish smoke, which shines in the dark; and which, being caught in a receiver, and condensed by proper cold, constitutes what we call phosphorus: which may be kept in water for twenty, nay forty years, without any diminution of its properties; but if expos'd to the air, immediately takes fire: whence it appears, that the mere attrition of the air may excite fire*.

5th

† Take some ounces of strong oil of vitriol, and shaking it with three or four times its weight of common water; tho' both the liquors were cold when put together, yet in their mixture they will immediately grow intensely hot, and continue considerably so for some time. Boyle Mechan. Orig. of Heat.

¶ Phosphori, in general, says M. Lémery, may be considered as so many sponges, full of fire, or the matter of light, which is so weakly retained therein, and by so slender a hold, that a small external force is sufficient to put it in a condition to exhale, in a lucid form, and sometimes even to burn the bodies that come in its way. Mem. de l'Acad. An. 1713.

* It has been above observ'd, that there is no body, which can be esteemed a magnet with respect to fire, i. e. no body which attracts it by any peculiar virtue, more than other; and yet our author here furnishes some considerations on phosphori, which seem to evince the contrary; at least as they are stated in the printed copy. "The fourth way of collecting fire, he observes, is in some measure magnetical, i. e. perform'd by means of certain bodies peculiarly disposed to im-

bibe, and retain fire. For that there is some peculiar agreement and attraction between fire and certain bodies, is evident, among other things, from black bodies, which, as already observed, absorb almost all the fire that falls on 'em, whereas other bodies reflect a great part of it, and some, all. Other instances of such agreement we have in the phosphorus Balduini, and Bononian stone; which when duly prepared have all the characters of attractives: thus, being immediately exposed in a dark place, they do not afford any light; but expose 'em first to the sun a while, and they will then shine in the dark, as having imbibed a stock of fire, and lodg'd it in their spongy substance, to be dispensed again by degrees. The like may be said of the phosphorus made of human urine, and other chemical preparations, which receive such a proportion of fire in the preparation, and retain it so well in their unctuous substance, that it shall keep there, in water, for 20 years: and upon the first laying it open to the air, take fire, and exhale in lucid fumes; leaving nothing behind but an acid malagma, like oil of

Fire collected by
the mixture of
two solid bodies.

5th Way of collecting fire, is by two solid, quiescent bodies, moisten'd a little, then ground, mix'd together, and press'd with a proper weight. Thus, if you take equal portions of steel filings, and sulphur in powder, moisten 'em with a little water sufficient to form 'em into a sort of paste, and thus hide 'em under ground, well press'd down; they will smoke, heave, and at last catch a vehement flame †. Dr. Lister, in his writings

“ sulphur *per campanam*, or oil of vitriol.
“ Not that we suppose the fire fix'd and
“ quiescent all the while in the body of
“ the phosphorus; for, that it has a real
“ motion all the while, is evident hence,
“ that if you observe it in any dark place,
“ in the summer time, you will find
“ it continually fulminating and emit-
“ ting flashes: tho' with all this it scarce
“ loses any thing of the fire. So that the
“ fire is not fix'd in the phosphorus, but in
“ a continual undulatory motion.

† “ By putting a considerable quantity
“ of dry salt of tartar, in the palm of my
“ hand, and wetting it well with cold
“ water, there has been a very sensible
“ heat produced in the mixture: and
“ when I have made the trial, with a large
“ quantity of salt water, in a viol, the
“ heat proved very intense, and continued
“ to be sensible for a long time after.
Boyle Mech. Orig. of Heat.

“ 'Tis known that salt-petre being put
“ into common water, produces a sensi-
“ ble coldness therein, as it doth also in
“ many other liquors; but the same
“ salt, put into a liquor of another consti-
“ tution, may have a quite different effect;
“ appears by mixing 8 ounces of fine
“ salt-petre in powder, with 6 ounces of
“ oil of vitriol: for here a salt, not only
“ actually cold, but with regard to many
“ other bodies, potentially so, mix'd with
“ oil of vitriol, which is sensibly cold
“ too; quickly conceives a considerable de-
“ gree of heat, whose effects also become
“ visible in the plenty of fumes, emitted
“ by the heated mixture. And tho' gun-
“ powder seems to be of a very fine na-
“ ture, yet if some ounces of it, reduced
“ to a powder, be thrown into four or
“ five times as much water; it will very
“ manifestly impart a coldness to it; as ex-
“ perience made with, as well as without,
“ a seal'd thermometer, has assured me.
Ibid.

“ I have made an experiment, says Mr.
“ Boyle, in which two liquors, whereof
“ one was natural, did, by being several
“ times separated, and reconjoined with-
“ out addition, at each conjunction pro-
“ duce a sensible heat. An instance of
“ this kind we have in salt of tartar, from
“ which, after it had been once heated
“ by the affusion of water, we abstracted
“ the liquor without violence of fire, till
“ the salt was again dry; and then putting
“ on water a second time, the same salt
“ grew hot again in the viol, and produ-
“ ced the like heat a third time, and might
“ probably have done it oftener.

“ Perhaps the heat may much depend
“ on the particular disposition of the cal-
“ cined body, which being deprived of its
“ former moisture, and made more po-
“ rous by the fire, acquires, by means of
“ those igneous effluvia, such a texture,
“ that the water, impelled by its own
“ weight, and the pressure of the atmo-
“ sphere, is able to get into a multitude of
“ its interstices at once; suddenly dissolve
“ the alkalizate salts it every where meets
“ with; and briskly disjoin the earthy and
“ solid particles that were blended with
“ them, which being exceeding nume-
“ rous, tho' each of them perhaps be
“ very minute, and moves but a very lit-
“ tle way, yet their multitude makes the
“ confused agitation of the whole aggre-
“ gate, and of the particles of the water
“ and salt, vehement enough to produce a
“ sensible heat. *Id. ibid.*

“ And the same that is here shewn of
“ heat, does likewise appear of its oppo-
“ site, cold. “ Mr. Boyle observes, that a more
“ intense degree of cold may result from
“ a mixture, than was to be found in ei-
“ ther of the ingredients a-part; and al-
“ so that a considerable coldness may be
“ begun between bodies, neither of them
“ actually cold before they were put to-
“ gether.

writings upon fossils, observes, that the pyrites contains iron and sulphur; whence it is, that when a little moisten'd it takes fire. And hence, according to him, the pyrites under ground happening to be wash'd by rills or streams of water, kindles, and explodes: and thus arise earthquakes, volcanos, &c.

These are the chief ways of collecting fire, from which appears how enormous the popular opinion is, that fire can only be produced either by the sun, or some fire already existing under the earth. We add, that the quantity of fire in the universe, is fix'd and immutable; and that in the instances now recited, we only collect more of it into one place, and consequently leave the less in another: so that the hotter one place is, the colder is another. Hence *Troy* cannot be burnt without robbing *Ida* of its fire: and thus water freezes so much the more readily, and the more strongly, as there is a greater fire not far off.

"gether. Having brought a glass full of
"water to such a temper, that its warmth
"made the spirit of wine in the sealed
"weather-glass manifestly ascend, I took
"out the thermometer and laid it in powder'd sal-armoniac, warmed before hand,
"whereby the tinged liquor was made to
"ascend much quicker than just before by
"the water; and having presently removed the instrument into that liquor again,
"and poured the warmish sal-armoniac
"into the same, I found, that within half
"a minute or less, the spirit of wine began to subside, and fell above a whole
"division and; below the mark at which
"it stood in the water, before the liquor
"or salt were warmed. Nor did the spirit in a great while reascend to the
"height it had when the water was cold.
Ibid.

"We took a small seal'd thermometer,
"whose stem was divided into equal
"parts, by little specks of amel, that sharp
"liquors might not eat off, nor spoil the
"marks. The ball of this instrument we
"put into a slender cylindrical vessel, and
"more than cover'd it with strong oil of
"vitriol; and left it there a while to be
"reduced to the temper of the surrounding liquor; then we cast upon it by degrees sal-armoniac well powder'd, which
"being soon furiously wrought upon by
"the menstruum, a seeming effervescence
"was produced in the conflict, with
"great noise and much froth, which more
"than once was ready to run out of the
"vessel. But for all this seeming ebullition, the mixture, instead of proving

"hot, did really grow gradually colder,
"as appeared not only to the touch, but
"by the descent of the tinged spirit of
"wine. But pouring this actually cold
"mixture into three or four times its
"weight of common water, which was
"likewise actually cold; this second mixture immediately grew so hot, that I
"could not keep my finger, for a minute
"or two upon the outside of the containing glass. *Id. ibid.*

"To 12 ounces of sal-armoniac we put,
"by degrees, an equal weight of water;
"and whilst the liquor dissolved the salt,
"and by the action produced a great coldness, we warily poured in 12 ounces of
"good oil of vitriol; whence a notable
"degree of heat was quickly produced in
"the glass, wherein the ingredients were
"mixed, though it seem'd unlikely, that
"the two liquors, which usually with sal-armoniac do each produce an intense
"cold; should, upon acting together,
"produce the contrary quality. *Id. ibid.*

"In most of the experiments hitherto
"proposed, cold is regularly produced in
"a mechanical way; but in some sort of
"trials, I found the event varied by unobserved circumstances, so that manifest coldness would be sometimes produced by mixing two bodies together,
"which at another time, would upon uniting disclose a manifest heat; and
"sometimes again, tho' more rarely,
"would have but a very faint degree of
"either. *Ibid.*

Away,

Away, then, with that empty dread, that the world may one day be consumed by fire: for, from what has already been shewn, 'tis impossible: We mean physically, so; and without setting aside the order of nature. Nor is the apprehension less vain, that we shall come at length to want fire.

Of the Pabulum, or Food of Fire.

Fire how it goes
out, and in what
law.

Fire, thus collected by attrition, &c. soon appears to perish: but in reality only disperses again, in which state, as already shewn, it does not affect our senses, and consequently perishes to us. Unless, therefore, the fire thus collected, be some way or other retain'd, it soon dissipates and disappears, which dissipation is found to be in the ratio of the density of the ignited body or medium, wherein it exists. Thus red-hot iron loses its heat much sooner in air than in *vacuo*; in water, 850 times sooner than in air; and in mercury vastly sooner than in water; and so of the rest: the extinction being always the quicker, as the medium is denser.

Sustained by
fuel.

Now, to prevent this dissipation of fire, it is to be sustain'd by some proper matter, which we call its *pabulum* or *fuel* ||. By *pabulum*, therefore, we mean any body, which applied to fire collected by any means, retains it in that state, and prevents its dispersion.

Fuel what.

Different from
fire.

Fuel after burn-
ing recoverable
again.

But this *pabulum* is not fire itself, nor is it at all convertible into fire: for if fire be set to spirit of wine, the whole of it will vanish, and be converted into flame; and yet the whole may be converted again into spirit by the application of proper vessels. And the same holds of sulphur, or any other combustible body, the minutest part whereof is not lost in burning; as appears from trying it in vessels exactly clos'd. In vessels open to the air, indeed, a great part is lost, being carried off in flame, smoke, &c. But this only arises hence, that the principles into which the body is resolved by fire, are volatile. Hence it appears, that the *pabulum* of fire is not converted into fire, notwithstanding, that a great part of it disappears, when lighted in the open air, and to vulgar eyes seems converted into flame.

Oil, or sulphur,
the only proper
fuel.

The only *pabulum*, or food of fire in all nature, is oil; commonly known under the name of sulphur*.

Thus,

|| " There are two ways of preserving fire; first by bodies, which receive and retain it, without being destroyed, or dissipated thereby: and such are phosphori, above mentioned. The second by affording it a continual supply of fuel, i.e. of matter proper to retain it, till being render'd volatile, and dispersed in form of flame, fresh matter is added. Boerhave, Cod. impr'ff.

* One great effect of the matter of light, diffused among terrestrial bodies, is, according to the younger Lemery, that being detained, and mix'd along with certain compositions of salt, earth and water, it therewith forms oils, fats, and in a word all inflammable matters, which are only such in virtue of the particles of fire they contain. What principally inclines us to this opinion, is, that in the analysis, such

Thus, in vegetables, which feed and sustain fire, there is no other inflammable part but oil. For the water and salt, if thoroughly purg'd of all the oil, are found to damp and extinguish fire: and as to the spirit, neither does this burn; and the earthy part, no body will imagine, should maintain fire; It may indeed retain it for a while; but no otherwise than as gold, or a stone ignited will do. Accordingly, extracting all the oil from a plant, it ceases to be any longer combustible.

This oil is found in two manners: first in a solid, and secondly in a fluid form: In the first, are the oils contained in all vegetable animal substances, and which appear in manner of a carbonaceous blackness. Thus, if you take a pound of the whitest wood, expose it in the middle of the fire, till it cease smoking, and then plunge it in cold water; the white wood first converted into a shining, glowing brand, will now be a black coal. And the blackness here, is only the oil of the vegetable rarefied by the heat of the fire, and spread o'er the surface of the earthy part of the vegetable. If the coal remain too long in the fire, the oil, too, will be dissipated, and nothing left but the bare white calx or earth.

The case is the same in animals, which have nothing inflammable in 'em beside their oil. Their water and salt, freed of all oil, do by no means sustain fire; and their earth is not at all combustible. Consequently, animals can burn no longer than they have oil. This is evident hence, that the bones of animals, which while they retain'd their oil, would burn more fiercely than wood it self; yet, when that is gone, so far are they from being combustible, that they make the greatest opposition and resistance to fire; as is evident from the refiners cuppels, which are made hereof.

For fossils, they, too, take fire, so far only as they contain sulphur: their earth, water, and salts do none of them burn: nay, and their very sulphurs, and bitumens remain incapable of firing, as to their saline and acid parts; and are only inflammable as to their oily ones.

From what has been said, we may gather, that oil is the only body in nature which can preserve fire; and consequently, in this view, oil may be deem'd a sort of magnet or attractive, with respect to fire †. Now, oil

such bodies, are reduced into salt, earth, water, and a certain fine subtle matter which passes thro' the closest vessels; so that what pains soever the artist uses not to lose any thing, he still finds a considerable diminution of weight.

'Tis certain that salt, earth, and water, whether united together, or separated, never become inflammable; but even hinder or retard it, in bodies that are inflammable. It may even be advanced, that these principles are of no use in the composition of inflammable bodies, but to detain and arrest the particles of fire, which are the

real and only matter of flame; and which only rises into the air under this form, when the inflammable body having been exposed to some external fire, has had its cells or vesiculæ broken up, and the contained fire set at liberty. It appears, therefore, to be the matter of flame that the artist loses in decomposing inflammable bodies. *Mem. de l'Acad. An. 1713.*

† M. Homberg, indeed contends, that sulphur or oil is fire it self; or that there is no sulphur beside fire. In the analysis of oils, says that author, their whole substance becomes reduced into a deal of aqueous

Oil, its quality. is a body whose parts are easily divisible, but which are so branchy and tenacious, that 'tis with difficulty they let each other quite go: in which it differs from water, whose particles are equally divisible, but not so branchy, nor catching so much on one another: as appears by pouring a little water on a polish'd mirror; for it may be wholly wiped off again, without the least stain; whereas oil, and all oleaginous bodies, as spirit of wine, balms, resins, &c. will still leave some mark behind.

Hence it becomes a fuel.

Oil, then, feeds and sustains fire by its particles being hook'd, and adhering to each other, so as to sustain the impetus or effort of the fire, which tends to divide and disperse them; and to be put into a rotatory motion, rather than let one another go: Which rotation is so exceedingly swift, that no body except fire can follow it with equal velocity. In the mean time the fire, during this rotation, does so comminute the oil, and break off its branchy particles; that being no longer glutinous or adhesive, they cannot hang together; and consequently become incapable any longer to sustain the fire, and thus are dissipated, and the fire extinguished; unless fresh fuel be supplied from time to time.

How consumed, and the fire extinguished.

Hence some oils are more inflammable than others.

The thinner oil is spread, the more readily it catches fire.

This oil, the purer and more subtile it is, the easier it is inflamed, and the fitter for feeding fire: Thus alcohol, the most subtile of all oil, catches flame at the smallest fire; For it is to be observ'd, that no oil catches fire, till it first be heated; and that the coarser and thicker the oil, the greater degree of heat must it conceive e'er it flame. And hence the reason why alcohol, so fine and subtile as it is, should take fire so readily.

The larger surface this oil is spread into, the sooner it takes fire; as is evident in certain bodies which catch, and nourish the smallest spark: For charcoal is nothing but earth thinly spread over with oil; or, it is oil it self, stretch'd over thin plates of earth, and thus extended to an infinite superficies; the water, volatile oil, and salt, being all first carried off: as appears from the very method of making charcoal. Thus, if you apply a paper to the fire, it first expels its watery part, in form of smoke: then yields a stench, and lets go its more volatile oils: then it grows brown; and at length, when nothing but the earth and oil remain, black. The oil being now spread into thin lamellæ, in form of a blackish soot.

queous matter, some insipid earth, and a little salt, partly volatile and partly fixed; the real principle sulphur, which connected these several ingredients together, to make an oil, being lost in the operation. The same befalls the sulphur, in all bodies whatever, that undergo a rigorous analysis; so that we have no positive way of arriving at the knowledge of its nature by the decomposing of mixt bodies: hence he was led to examine it, by making artificial mixts or compositions. And the result, he assures us, of a great number of

operations of this kind, give him plain indications, that 'tis fire is the principle sulphur, and that this is the only active matter in all bodies.

To support this opinion, he endeavours to shew that fire, or the matter of light, is always in motion and action; and that this matter may be introduced into the other principles, change their figure and augment their weight and bulk, and connect 'em together, so as to produce all the mixts which fall under our observation.

Mem. de l'Acad. An. 1705.

There

There is no body feeds a sparkling fire like charcoal; nor any body that catches a spark so readily: not sulphur it self. And hence, to render gunpowder the more easily inflammable, the finest charcoal dust is added to the other ingredients, nitre and sulphur. *Coal its quality.*

Now, coal may be either made of the parts of animals; or vegetables; *How made.* by only burning 'em to a blackness, and then extinguishing the fire: or, by making 'em undergo the greatest degree of fire possible, in a close vessel. Those chiefly used for a ready susception of fire, are made of linnen cloth *Kind: thereof.* burnt to a blackness, and then immediately extinguished; or of small wood, particularly the branches of beech, burnt in like manner, and then pulverized: either of which catch the smallest spark of fire.

1^o, The finest, and subtlest sort of coal, is that made of paper, burnt to its utmost blackness, and then extinguish'd. This will catch the feeblest spark.

2^o, Linnen burnt, and extinguished in the same manner, affords a pure coal, which very easily takes fire.

3^o, Soot, which is nothing but oil it self sticking to the chimneys, readily burns; as plainly appears from conflagrations, which frequently begin in foul chimneys, from a single spark of fire.

Which Bodies are *Pabula*, or Fuel of Fire.

1^o, ALL vegetables, without exception, afford a food for fire. *Jul. Caesar, All vegetables indeed, and the elder Pliny, relate of the larch-tree, that it will not burn; but this is directly false, the tree abounding very much in oil.* *combustible.*

But the drier, and more ponderous vegetables are, the more lasting fire do they afford; as containing the more, and the purer oil than those lighter, &c. And hence, the more oleaginous trees, which yield balm, pitch, &c. are used to be call'd *tadae*, torches. If, then, the oil be spent, either thro' time, the air, worms, or the like, and the wood turn'd carious, it becomes unfit for burning. So also, if a vegetable be despoiled of its oil by distillation, coction, &c. it will never burn. But add some of this oil to a body before no ways inflammable, *e. gr.* to mere ashes, and they readily take fire. Green wood is usually held incombustible; and yet if it stay in the fire long enough to have its aqueous particles evaporated, it burns better than dry. The reason is, that in the usual drying, and withering, not the water only, but some parts also of the oil are exhaled.

While a vegetable is burning, the fire not only moves the oil, but also agitates and drives, in a sort of vortex, all the branchy parts in the vegetable; and hence its effect becomes the greater, and the destruction it makes more considerable. But it preys on the oil in a more especial manner, by reason the tenacity of its particles make it a kind of focus. And hence the flame, burning bodies put forth, is not fire, or oil alone: for first, after the body is kindled, smoke arises, which, with the increase of fire, at length turns to flame. And smoke, in its passage up the chimney, leaves soot behind, which by distillation, yields a volatile salt, an inflammable spirit, earth, and two sorts of oil; which shews, that the flame did not consist of oil alone. *Fire agitates other parts of the vegetable beside the oil.* *Its effect increased thereby.*

M m

fire

fire does not act merely by its own matter, but by those spicula, and pieces of bodies, which it whirls round, and at length darts forth.

Charcoal, a fuel. The 2d pabulum of fire, is *charcoal*, prepared from vegetables; and all other coal prepared of the bones of animals which have oil in 'em, and are capable of turning black by burning. For, such as do not become black in the fire, it is to be observed, instead of feeding, do really suffocate, and

How prepared. put out fire. The manner of preparing charcoal is as follows. A quantity of any kind of green wood being heap'd up into a pile, with a little dry intermix'd, to make it kindle; and the whole cover'd, externally with a coat of turf; fire is set to the same: when the whole heap is found sufficiently ignited, they extinguish it again, by casting in earth, and shutting out the air. By this means the whole heap is converted into black coal; whereof, that is most priz'd by the chemists which is made of beech: next, that of oak.

Its poisonous quality.

There appears to be something poisonous in these coals; for when kindled, they exhale a vapour, which if it be kept up, and confined in a close place, causes vomiting, makes a man reel, and at length suffocates and kills him. The nature of this poison is perfectly unknown: *Helmont* calls it *gas sylvestre*.

Yet, is this a very commodious fuel; as it maintains the fire pure, and makes it easily governed.

Turf,

3^o, *Turf*, whereof there are two kinds: the first, a glebe, pared from off heathy grounds, in shape of a parallelopiped; which may be reduced to the vegetable kind. The second is dug underground, in a kind of fenny places, called *meses*: In peat-mosses, there is a stratum some foot deep call'd *black-peat*, which being dug up with proper spades, and dried in the sun, affords

Peat.

Its nature and principles.

a fuel. It consists of a fat, muddy, blackish earth, and seems to have a share of sulphur: and the sulphur always contains bitumen, which is a sort of neutral between sulphur, and vegetable oil. The basis, then, is an earthy matter, which contains fossil salts: but for the rest, it is of the vegetable class. The greatest quantity of sulphur is in that kind which yields ruddy ashes not unlike *crocus martis*: the steam or smoke hereof is plainly sulphurous, and tinges the countenances of persons sitting by it with a paleness like that of death. But that sort which yields white ashes, is the best.

Its Origin.

As to the history of turf, or peat: by the pieces of putrified wood, frequently dug up along with 'em, and by the histories remaining of this country, which represent it as anciently cover'd with woods; 'tis more than probable the places where turf are now found, were formerly woods, or forests; which shedding their leaves, and at length the trees themselves tumbling, they became cover'd over with moss, and thus, in process of time, sunk to their present depth †.

Dutch turf its peculiar qualities.

The *Dutch* turf have this peculiar to 'em, that when thoroughly fired, they yield no smoke, but bear the fire with great firmness for some hours; when, at length, they fall to ashes. For this reason, Mr. Boyle us'd to procure 'em, for his chemical experiments, from *Holland*. But their smoke, when but half lighted, is extremely noxious; and especially in a close place:

† An account of a peat-moss form'd expressly in this manner, in *Scotland*, is given us by the Earl of *Cromarty*, in the *Philosophical Transact.* N^o. 330.

inasmuch,

insomuch, that it will suffocate an animal inclosed therein, without any pain or perception thereof.

4^o, To these must be added *fossil* or *pit-coal*, dug out of pits or mines, in ^{Pit, or sea-coal,} form of a heavy, black shining glebe; seeming to be a species of semi-metal or pyrites: it contains a large quantity of sulphur, which yet is different from the common sulphur, in that it has less of the acid, and therefore does not suffocate so soon. It feeds a flame so long as it remains black; but no longer: the flame bearing a near resemblance to that which nitre gives. The more close and compact these coals, the more vehemently they burn; they are supposed to have somewhat of a metallic nature in 'em, by reason they make such considerable alterations in bodies*.

To this class likewise belong common sulphurs, bitumens, asphaltes, amber, naphta, petrol, agat, &c. which are a purer sort of fossil coal, and burn accordingly; they contain an acid spirit good against the plague, but pernicious to the breast.

5^o, The *fat* of all animals, which burns in the fire: and the oil of fishes, ^{Fat,} as whales, &c. used to feed lamps.

Hither, likewise may be referr'd the dung of animals, which feed on ^{Dung,} herbs; which, dried in the sun, takes fire, and flames. These dungs, particularly that of cows, are burnt as the common fuel in some of the northern countries; but their smoke is hurtful, and extremely fetid.

6^o, We may add, the several productions which chemistry furnishes from ^{Divers chemical} oils. Such is alcohol, the last effect of the chemists fire, which burns quite ^{substances.} away, without any fume, or leaving any faces. Camphor, petroleum, &c. do yield a fume.

Now, as the pabulum of fire differs, the effects chemistry produces by it, are found to differ.

Thus, the fire of alcohol is the purest of all we know of, and is not capable of being heightened: the next are the oils of vegetables, which, the ^{Fire different as its fuel is more or less pure.} purer they are, the purer fire do they afford.

But 'tis impossible perfectly to purify an oil, or draw all that is heterogeneous out of it: there will, at least, a share of water perpetually remain, which is perfectly incombustible. But in alcohol there is neither salt nor earth, nor water; and accordingly it is the only perfectly inflammable matter in the whole universe. The next are oils distill'd *per vesicam*: for in boiling and shaking in the water, they lose their salt and earth, and become so much the purer, as the distillation is the oftener repeated.

* "The smoke of pit-coal being very offensive, and other inconveniences attending its use; a way has been found to char and reduce it into coherent masses, of a proper size. 'Tis true it is sold almost as dear as charcoal; yet those who consume large quantities, find it near twice as cheap, because it lasts much longer, and gives a heat far more intense. It would therefore be a very useful thing in chemistry, to be able to char coals, without the use of those pots to which their present price is owing. In Holland they have, likewise, a way of charring peat, a kind of turf, which might serve for fuel in chemical operations, tho' the manner of charring be not yet known in several countries, where, perhaps, peat might be found. Boyle, *Useful. of Exper. Philosoph.*

1°, The purest of all fires, then, is that collected from the sun, which always remains immutably the same, and needs no pabulum to sustain it.

2°, Next to this, we rank the pure flame of alcohol.

3°, Then, the fire procured from distill'd oils, well purified.

4°, Charcoal yields a tolerably pure flame, being purg'd of its water, and salt, and nothing but oil and earth left.

5°, Turf.

6°, The most impure of all is pit-coal.

The Effect of Fire different, as the Fire is of a different kind.

Diversity of the effects of fire.

ALL these things are to be well known, and distinguish'd by the chemist; the success of any experiment, depending very much on the diversity of fire: for tho' all fire, in it self, be perfectly similar, and consist of homogeneous parts, yet, the same individual fire being retained successively in several pabulums, will have different effects; in as much as it acts by different mediums. So that tho' fire admit of no diversity, considered as fire; yet it does, consider'd as to the bodies it is inherent in. Even reason would tell us, that the effect must be different, if the operation be performed with fire of alcohol, from what it would be with vegetable turf. Mr. Boyle, in his treatise of the unforeseen failure of certain experiments, concludes, that a great number of experiments, successfully executed by some, have failed in the hands of others, merely from their using a different kind of fire. Thus wood, burnt in a naked fire, yields a smoke, which collected in a close place, does a man no harm; unless, perhaps, it may offend his eyes: but if the coals be extinguished under water, or a weight of stones, and then kindled again, their smoke is certain death, so that the same fire, of the same matter, in the same quantity, and the same place, makes different changes in the same objects. So an animal being inclosed in the half exhausted receiver of an air-pump, if a quantity of the smoke of turfs be thrown in, it will soon be killed; but not with a like quantity of the smoke of wood.

Differences of smoke.

Blowing the fire.

Nay, the very manner of blowing a fire, makes an alteration in its effects. Thus, we have it from *Acofta, Lib. IV. c. 5.* that the silver, from the mines of *Peru*, cannot be fused by a fire blown with bellows, but only by fire blown with a wind raised by the fall of a cataraft. In order to this, they lay conduit-pipes from the tops of rocks, thro' which the water descending, agitates the air, and thus raises a constant wind, which is taken up by certain tubes disposed for the purpose, and thus directed to the fire, which, by this artifice, readily melts the metals. And 'twas, probably, on some such like account, that the gold, brought some years ago from *Portugal* into *England* and *Holland*, could not be melted in either of those places, and yet in *France* was managed easily enough.

Casting water on it.

Water thrown plentifully upon fire, extinguishes the same; as compressing the oils, and hindering their rotatory motion. But if the water be thrown

thrown on sparingly, the fire, in that case, overcoming the resistance, breaks out with the more vehemence ||.

Air has a very great effect in the varying of fire: Thus, the heavier the air is, the more violently fire burns; and the lighter, the less: *in vacuo* it scarce burns at all, unless some way collected, either by being reflected or refracted.

When the atmosphere is lightest, and the barometer stands the lowest, then is the action of fire the weakest; and yet even then it is much greater than *in vacuo*. This diversity, in respect of the ambient air, is particularly observed in the fusing of metals; it being known, that at one time they will run much sooner, and with less fire, than at another. Yet is not air the soul of fire, as *Centivoglio*; nor the pabulum of fire, as other philosophers; nor any way conducive to the production thereof, as the generality of people imagine. And as to what is urg'd, that upon removing the air, the fire immediately perishes; it is not universally true †; as appears from the observation of Dr. *Stare* and others, who find that fire may be produced *in vacuo*, by mixing the spirit of nitre with an aromatic oil*. Add, that phosphorus still burns *in vacuo*; and that the more they take away the air from

Air, how it affects fire.

Weight of the atmosphere.

Fire producible without air.

Phosphorus.

|| In the experiment of the phosphorus, we observe, that water acts on the fire contained in the phosphorus; in that it keeps it in, and prevents its consumption, and dissipation. Hence, as soon as the water is taken away, the heat and smoke immediately confess that the fire is breaking out. Add, that air it self does also seem, in some measure, to keep in the fire contained in hot water; and hinder it from escaping so fast as it does *in vacuo*: Thus, heating two equal vessels of water equally, and then putting one of them in a receiver; as you exhaust the air, the water will boil vehemently, and soon become barely lukewarm; while the other remaining in the open air, has neither boiled nor lost any sensible part of its heat. Something like this is observed in shining wood; for some wood having rotted in the ground, shall shine very briskly when taken out; the fire having been kept in by the contiguous earth: but in a day or two's continuance in the air, it spends all its light, and ceases to shine. 'Tis hard to say how fire should thus be confined by ambient, loose, porous bodies; or by what action such bodies should produce this effect: pressure, one would imagine, should be altogether inadequate, since it has been shewn that fire by its extreme subtilty, can readily penetrate thro' all, even the most solid bodies. *s'Gravesand, ibid.*

† The truth is, in some cases, the presence of air is necessary for the production of light, or preservation of fire: as appears from the burning those bodies which go out when the air is taken away; thus a lighted candle being put in a receiver, and the air exhausted, the candle is immediately extinguished: nor will the ordinary attrition of a flint and steel produce any spark of light *in vacuo*. On the contrary, on some occasions the absence of the air is necessary to light: as will be shewn hereafter. Lastly, in other cases, the light which was before seen in the air, becomes augmented upon taking away the air: as we see in the lucid lines drawn by phosphorus. *s'Gravesand, ibid.*

* "For the sake of those who think the attrition of contiguous air necessary to produce a manifest heat, we placed some hard black pitch in a basin, at a convenient distance under water, and cast the sun's rays on it with a burning glass, in such manner, that, notwithstanding the refraction they suffer'd in passing thro' the water; the focus falling on the pitch, would produce sometimes bubbles, sometimes smoke, and quickly communicate a degree of heat, able to melt it, if not also make it boil. *Boyle, Mech. Orig. of Heat, &c.*

it.

it, the brighter still it shines. Beside, that fire must be very copious in the regions about the sun, where no body will expect to find air*.

How air contri-
butes to fire.

All the use of air, then, in our vulgar fire, is to make a kind of *fornax* or vault around it, and thereby restrain and keep in the oily particles, and prevent their flying off too hastily. Hence, upon a total removal, or even a diminution of the pressure of the air, that fire goes out: and hence it is, that the same portion of air shall not always be able to maintain the same fire; in that, air being rarified by heat, its pressure becomes diminished. This pressure, and repression, is continued so long, till the pabulum be broke small enough for it to pass thro' the pores of the air, and so fly away. When this happens, we say the fire is spent, *i. e.* the combustible part of the fuel is diffused thro' the pores of the air; and the fire, of consequence, turn'd loose and vague again.

How fire goes
out.

Bellows, their
effect.

Air, therefore, acts no otherwise on fire, than as it confines, and keeps in the pabulum: And hence, the heavier the air, the fiercer the fire, and *vice versa*. And thus we see why bellows vibrate the fire, and increase its flame: for new air being thus forcibly thrown in, and the atmosphere, by this means, coming to press nearer and closer, drives the combustible matter into less compass, and so lays it more obviously exposed to the fire.

Culinary fire its
nature and phe-
nomena.

And hence we see what our culinary fire is; *viz.* a congeries of the infinitely minute particles of elementary fire, forcibly thrown on a matter capable of liquifying by fire: which agitating and whirling round the oily particles of the fuel, divides and attenuates 'em; the agitation, withal, being so swift, that nothing but fire can keep pace with 'em; so that a collection, or continual accession of fire, is hereby made. By this agitation, the harmonious parts of the oil are gradually broke off, and thus the whole, at length, are rendered volatile; the vault of circumambient air, all the while compressing the said particles with its own weight, which is equal to 32 cubic feet of water, or 29 inches of quicksilver, and thus retaining and repelling 'em, and collecting them about the place. And if this pressure of the air be increased by any art, as by blowing with bellows, &c. the fire will be the greater.

If one of the above-mentioned circumstances be wanting, the fire must go out: Thus, if the vault be wanting, there will be no triture; or, if it be too much increased, then the particles of oil being incumber'd, will become unfit for the brisk rotatory motion necessary to sustain fire.

* " We took a pistol, and having firmly
" ty'd it to a stick almost as long as the
" cavity of the receiver, we prim'd it with
" dry gun-powder; then cocking it, we
" fastened the trigger to one end of a
" string, the other being fastened to
" the key in the cover of our receiver:
" this done, we conveyed the whole ap-
" paratus into the vessel, which being
" closed up, and emptied after the usual
" manner, we turn'd the key in the cover,
" and thereby shortning the string, pull'd
" the trigger, and observ'd, that the force
" of the spring of the lock, was not sensi-
" bly abated by the absence of the air; for
" the cock falling with its usual violence,
" struck as many, and as conspicuous
" sparks of fire, as, for ought we could
" perceive, it did in the open air. Upon
" often repeating this experiment, we
" could not perceive, but that the sparks
" of fire moved upwards, downwards, and
" sideways, as when out of the receiver.

Boyle, *Phys. Mech. Exper. on Air.*

The

Fire itself, we know, naturally rarefies the adjoining air; and repels, or drives it off, especially when any flame arises; and thus makes a sort of *vacuum*, in the middle whereof is the fire and fuel. But action and reaction being equal, the more the fire impels the ambient air, the more does the air repel the fire: And thus is the attrition increas'd. So long, therefore, as there are oily parts remaining in the fuel, i. e. parts not comminuted or subtilized enough to be thrown off, so long the fire remains.

The greatness or smallness of the fire, therefore, depends on the greater or less quantity thereof collected into one place or *focus*. In effect, we can scarce imagine it possible to increase or diminish any of the properties or the motion of fire: So that these must be look'd on as out of the question.

Fire, thus collected, and thus sustain'd by fuel, after it has done burn- *Relicks of fire* ing, leaves two kinds of matter behind it: 1^o, ashes; and, 2^o, smoke.

Ashes are the fixed salts and earth of the fuel; and smoke the volatile *Ashes* oil and water thereof.

Smoke, pass'd thro' the fire again, catches flame, and may thus be burnt *Smoke* or consumed quite away.

It is observed, that gross bodies, when they yield their utmost flame, afford both smoke and ashes: when the flame is more moderate, the fuel, withal, being supposed well ignited, they only afford a very light smoke; and when the flame is dwindled to a very small degree, they yield nothing but ashes. The smoke is only such parts as cannot be dissolved in the fire, by reason the fire has not yet attain'd a sufficient velocity; and hence it appears chiefly when the fire is first lighted; and disappears again, when that has arrived at its pitch. Hence, also, if the fire be sufficiently fierce, when new fuel is thrown on, no new smoke shall arise; there being force of fire sufficient to dissolve it. Add, that the degree of fire is precisely according to the quantity of the smoke; and the greater the smoke is toward the beginning, the greater will the fire be, when it has attain'd to its velocity.

Direction of Fire.

IT being already shewn, that fire is the principal instrument in che- *Fire, how to be mistry, it naturally follows, that its force is to be directed according used in chemistry* to the intention of the operation. Now, the force of fire depends on the greater or less quantity thereof, collected in the same place: for we hardly conceive it possible to increase or diminish its motion, and make any alteration in that respect.

The whole art of chemistry, then, consists in collecting and directing fire to a degree suitable to the divers occasions: For it is evident, at first sight, that the degree of fire necessary to fuse metals, is by no means proper to produce spirit of wine.

We are indebted to the mathematicians for a method of estimating fire, *How estimated* and of raising and keeping it up to any degree at pleasure: This is done by means of the thermometer, the use whereof the ancients were unacquainted with.

The

Four degrees of
fire.

The chemists usually reckon four degrees of fire; the three former whereof may be measured geometrically, by the thermometer: but the last is too violent for the thermometer to endure; so that we are here obliged to have recourse to another kind of register.

The various Degrees of Fire.

1^o, That of a
healthy man.

Or a brooding
hen.

Its use.

THE first degree is that equal to the warmth of a healthy body. This is determined by applying a thermometer to the person's mouth, (which is to be shut) and holding it there till the heat of the body be communicated thereto: Then, noting the degree, on the scale; the fire, in the furnace, is to be rais'd till it bring the spirit in the thermometer to the same degree. This degree is also had, by applying the thermometer under a hen brooding over her eggs; so that some, by keeping the fire constantly to this degree, have hatch'd chickens out of eggs without any incubation. By this fire, all digestions, easy separations, solutions, gentle distillations, fermentations, and putrefactions are effected. For this reason it is said to be the digestive fire, or that which separates into homogeneous parts.

'Tis this which makes all things live and grow. This fire was taken notice of by *Hippocrates*, who observes, that bread and life are effected by a gentle fire.

2^o, That of a
person in a fe-
ver, or a hot
sun.

Its use.

The **second degree** is that which affects the body of a sound person with a sense of pain, but without destroying the parts: Such is the heat of a feverish person, or that of a summer's sun, which scorches, inflames, and blisters the skin. This is a Mean between the heat of the first degree, and the third, which is that of boiling water; and therefore is easily determined by the thermometer.

This degree serves to make solutions and separations of the harder and heavier bodies, which the former is not equal to; as also to make fixations of some others, as mercury, by a gradual introducing of fire into the same: It makes the serum of the blood, or the white of an egg to coalesce; and thereby causes deadly inflammations. But digestions, fermentations, and putrefactions cannot be effected hereby.

3^o, That of boil-
ing water.

Its use.

The **third degree** is that of boiling water, which destroys the parts of animal bodies, produces mortifications, and death. This degree is perfectly stable, and permanent; nor is there any increasing thereof by any art. As soon as water has attain'd the degree of boiling, provided it be pure, it is not capable of conceiving any further heat; tho' an hundred times the fire were applied; as was first discover'd, by help of the thermometer, by *Monf. Amontons* *.

This degree of fire serves, in many cases, to separate, attenuate, and fix; and is used in other operations, where the former degrees are too weak.

* But different liquors under the same state are very differently hot: Thus, the heat of boiling water is scarce one fourth of that of boiling oil of vitriol; the latter raising the spirit in the thermometer to 540 or even 560 degrees; and the former only

to 130. And yet the heat of boiling mercury exceeds them all by many degrees: Heat beyond this, is scarce measurable, (in regard it bursts the thermometer) excepting by the fusion of the different metals. *Boerhaave Cod. Impres.*

The

The fourth degree is that which destroys all things, except metals; which, ^{4°, Fuses metals.} however, it fuses. And hence this degree is ascertain'd from the fusion of metals; for the thermometer cannot measure it, as not being able to bear such a force of fire, without perishing itself. As the degree of boiling water cannot be heighten'd, so neither can that of melted metals: for as soon as they begin to run, they have already conceived the utmost degree of heat they are capable of. In other respects, however, this degree is very indeterminate; inasmuch as different metals require different degrees of fire to fuse them. But these different, or subordinate degrees, we have no way yet of measuring precisely.

This degree serves in a great number of operations, particularly about ^{its use.} metals; where the other three are too slack; and is the utmost degree known in any of the preceding ages. And as the former degrees are determined by the thermometer; so is this by the melting of iron or copper, which, of all others, are the hardest of fusion †.

But, to these four, a fifth degree has lately been added, which not only liquifies, but even volatilizes all metals; making them fly off in fumes. In the year 1690, M. *Tschirnhausen*, a German, invented a sort of burning-^{Olympic fire.} glasses, in whose *foci* nothing would remain fix'd, but even gold itself evaporate: And this is the last and highest degree of fire yet discover'd.

Beside the five above-mentioned grand degrees of fire; there are a great number of other intermediate ones; which are easily known, and determin'd.

Of changing the Degree of Fire.

THERE are five principal ways of varying the degree of fire.

1°, By the *different weight of the fuel, or pabulum*; the rule ^{Five various according to the weight of the pabulum.} whereof is this, that the heavier the fuel, *ceteris paribus*, the more intense the fire. Thus, spirit of wine affords a weaker, gentler, and less destructive flame, than oil of turpentine; and this, again, than pitch or resin.

Spirit of wine only burns in its surface: Whence, the amplitude or extent of surface being given, the degree of fire it will raise, is easily found. Nor will this degree at all vary in equal surfaces, unless there be a difference in the density or lightness of the fire: So that the flame of spirit of wine may be kept to the same degree for years together; excepting for what alteration shall accrue from changes of the atmosphere.

After the fire of this spirit, we have gentle ones from all light, porous bodies, as hairs, feathers, spongy woods, &c. The last and utmost is that of metals, which imbibe so much the greater fire, as they make the greater resistance thereto.

2°, According to the *quantity of the fuel*: It being a rule, that the ^{The quantity of fuel.} greater the quantity of fuel, *ceteris paribus*, the stronger the fire. Thus,

† The four chemical degrees of fire are sometimes also taken from the different states of the human body, and estimated by their effect thereon: In this view, the first degree is that of a healthy person; the second, that of a feverish person: the third, that of a part inflamed; *e. gr.* by hot water: the fourth, that of boiling water.

a larger quantity of coals contain more fire than a less ; inasmuch as the former collects more than the latter.

According to the
distances of the
fire.

3°. According to the distance of the fire from the object, in this proportion ; that the greater or less the distance of the fire from the object, the greater or less is its heat in respect of that object ; and this, according to the *English* philosophers, in the ratio of the squares of the distances. Thus, if fire be one foot distant from a body ; and then removed to two feet : its action in the latter case will only be one fourth of that in the former. So, if removed three feet, it will be diminished nine times ; if to four, sixteen times, &c.

But we have made several experiments to this purpose ; in all which the rule has been found to fail. The reason of the failure is this, that the intenseness of heat does not depend altogether on the quantity of the fire, as the rule supposes ; but also on the nearness of the fiery corpuscles to each other, which makes them act with a new force : as has already been observ'd.

Thus, if you have two little fluctuating fires, their force will be found considerably greater when join'd together, than when at a distance from each other : For, in such case, they do not only act as two fires, *i. e.* with double the force of either ; but as they assist, and increase each other's force by a sort of attraction which is between them. And for this attraction, no rule or canon was ever assign'd.

The quantity of
air.

4°. According to the quantity of air blown into the fire ; the rule whereof is, that the greater the wind, provided it be not such as may break the aerial vault incumbent on the fire ; the greater, *ceteris paribus*, is the fire. For, by violent blowing, the combustible particles are put into the quicker motion : and by this means a great attrition ensues, and consequently a greater quantity of fire is collected. The fire, therefore, must be the brisker ; but, at the same time, the *pabulum* consumed the sooner.

The density of
the medium.

5°. According to the solidity of the medium, or body interposed between the fire and the object ; after this rate, that, the more solid the intermediate body is, the greater heat, *ceteris paribus*, does it receive from the fire, and communicate to the object. Thus, a vapour-bath communicates a less degree of heat to the body to be distill'd, than a water-bath ; and this, less than a sand-bath ; and this last, less than a bath prepared with steel-filings. For all bodies, exposed to the same fire, conceive heat in proportion to their several specific gravities. And hence, if a piece of metal, or stone, or sand, be put in water, and both be set to the fire ; by that time the water is barely warm, the metal or stone will be past touching. And thus it is, that keys, in the pockets of persons sitting by the fire, are frequently found very hot, while yet their clothes are but little the warmer.

If it be ask'd why this does not hold in mercury, a body much heavier than all stones or metals, except gold ; and yet not susceptible of near their degree of heat ? We answer, that it is of so fluxile and volatile a nature, as not to stand the action of a strong fire long enough to conceive its utmost heat ; but flies off in fumes upon the first approach of fire : And hence the

intenseness of the heat of a bath of iron or steel-filings; that matter being very heavy, and at the same time not easy of fusion.

On the footing of this rule of the density of mediums, the gentlest fire we can make, is in air. For, if you have two equal cylinders, the one full of water, and the other of air, and expose them both to the fire; that with the air will not heat near so fast as that with water.

Next to air comes spirit of wine, which is lighter than water.

And hence the invention of *chemical baths*, which are divided into air, ^{Baths.} vapour, and water-baths; the effects whereof may be increased to boiling water.

From what has been said, the manner of managing fire will be easily conceived.

The highest degree of fire, is that which calcines all bodies; which can only be had from the sun: as in *M. Villette's* mirror, &c.

The least degree we have known, is that observed about fifteen years ago, by the thermometer, in *Ireland*; the spirit rising scarce so high as one division.

Now, fire, acting in such various degrees, produces various operations: For the same which gives life to a man frozen with cold, is able to kill one in a due state of health.

It is a celebrated question, long controverted among the chemists, Whether fire, when applied to bodies, does only separate their parts; or whether it does not likewise change them? Mr. Boyle has labour'd the point in his *Sceptical Chymist*, and shewn beyond contradiction, that fire changes ^{Fire changes bodies.} and compounds, as well as separates. And this single consideration one would think sufficient to evince it; viz. that in acting upon several bodies, it insinuates itself into them, and fixes in them; so as easily to compose one body therewith. Thus lead remaining over the fire, after fusion, increases in weight: And thus salt of tartar, tho' by the first fusion it lose of its weight, yet coming afterwards to be calcined, it gains; and this the more, the more it is calcined. Add, that *phosphorus* must needs borrow its shining parts from the particles of fire fixed therein during the distillation: for it cannot be supposed to have pre-existed so in the human body. Nor are the productions of fire simple, as most have imagined: Thus, that celebrated one salt, is reducible into spirit and earth; and oil into water and earth.

This fire is not an universal dissolvent, but a comparative one only. For, ^{Fire does not dissolve all sorts of bodies.} 1°, If gold and silver, melted together in the same vessel, remain in a continued fluor for months, they will be never the nearer to a separation. ^{Nor separate all.}

2°, What it does dissolve, is not reduced thereby into its last elements or corpuscles.

3°, It mixes abundance of things which before were not mix'd; e. gr. ^{Mixes bodies.} mercury and sulphur, into cinnabar.

4°, It conjoins divers things: which are easily separated again by other ^{Conjoins.} means; e. gr. gold and silver, which *aqua fortis* separates.

5°, It unites some things, and separates others, according to the degree ^{Unites, or separates, according to circumstances.} it is in: Thus, it must be in a moderate degree to mix melted gold and silver; and in the highest, for mercury and sulphur.

Nay,

Opposite effects
from the same
degree.

Nay, and the same degree shall have opposite effects : Thus, a vehement fire shall render water, oils, salts, &c. volatile ; and yet the same convert sand and a fixed alkaline salt, into glass, which is a body almost immurable by fire, air, and all other bodies.

Different effects
according to the
manner of ap-
plication.

6°. It varies according to the application : Thus, it will not kindle sulphur in a close vessel, but with ease in the open air.

Fire, therefore, is no universal solvent : for it fixes, as well as volatilizes ; unites as well as separates ; compounds as well as analyzes : And further, fire is not a pure or sincere dissolvent ; as it does not separate the parts, without making alterations in them. Thus, if you resolve wine into its principles, *viz.* oil, water, spirit, &c. and reunite or remix these principles again, you will by no means have the same body as before.

We cannot therefore say of any production of fire, that it existed in the body before—Consequently, the productions of fire are not simple.

Nor does fire render all things volatile : The *Adepti*, for instance, have found, that the first matter or basis of metals, *viz.* mercury, which by a vehement heat evaporates ; if urged by a gentle equable one, as that of the first degree, long continued ; becomes united or incorporated with its sulphur, into a fixed mass ; which the second degree fixes yet further ; the third further still ; and the fourth only fuses *. Again, if you take a quantity of oaken-wood, slit it into thin shivers, and expose it for some years to the air, and then burn it ; you will get no fixed salt from the same ; and yet the same wood, burnt green and new, will afford a large quantity of fixed salt. So that, in the latter case, the fire seems to have fix'd the salts, which before were volatile.

Hence, according to the various degree of fire made use of, various productions arise.

GENERAL COROLLARY.

BY this fire hitherto described, we are able to separate, or unite, these, or those bodies, and produce these, or those effects : But we cannot say of fire universally, that it burns, it unites, or it separates ; for this would be contrary to experience : The utmost we can say, is, that a certain degree of fire, applied to a certain body, has this or that particular effect. The nature of the object, of the fire, and of the medium, are all necessary to be taken in, and consider'd : And yet, were we sure of all these, even then there are other particular circumstances enough to prevent our asserting any thing universally.

* “ Common quick-silver, being duly
“ purified with iron and antimony, be-
“ comes more fluid and active than before ;
“ and yet, putting this same mercury to
“ digest by a proper heat, we find, that,
“ without the addition of any other mat-

ter, it will gradually cease to flow,
“ and at length change into a fix'd pow-
“ der, which weighs more than the mer-
“ cury at first did ; and which will even
“ bear to be kept red-hot the space of
“ twenty-four hours. *Homborg. ibid.*

Of AIR.

WE now come to consider *air*, which is the second universal *Air*. instrument of chemistry; there being no operation performed by fire, without the intervention of air: unless, perhaps, those few done in the exhausted receiver of an air-pump.

By *air* we mean all that fluid expanded mass of matter which surrounds our earth, in which we live, and walk; and which we are continually receiving and casting out again, by respiration. *Defined.*

This mass consists of three different kinds of matter; viz. 1°, Of *fire*, *its constituent* which is an inseparable concomitant of air, and is equally diffused thro' *parts.* the same; 2°, Of *exhalations*, raised from all kinds of bodies; and 3°, Of a certain aerial matter, or *air* properly so called*.

Air, therefore, may be considered in two respects; either as it is an universal assemblage or chaos of all kinds of bodies, or as it is a body indued with its own proper qualities.

Fire in AIR.

I. **T**HAT there is fire contained in all air, is evident from what has *Fire.* been already shewn of fire's existing in all bodies, and all places: in effect, 'tis to this fire, that air seems to owe all its fluidity; and were *The cause of the fluidity of air.* that fire totally removed, it is more than probable the air would coalesce into a solid body. For we find, by actual experiment, that the air condenses, and contracts it self so much the more, the less degree of warmth it has; and on the contrary, expands it self the more, as the heat is greater.

Thus, in all the intermediate degrees, from animal warmth, to the utmost degree of cold art is able to produce, we constantly observe, the air to grow continually more and more contracted, denser and heavier; and consequently nearer to the nature of a solid: But the little degree of fire still remaining, continues active, and thereby prevents a

* Not unlike to this, is that division of the Atmosphere. The second may be yet Mr. Boyle: The atmospherical air that author conjectures to consist of three different kinds of corpuscles: the first, those numberless particles which, in the form of vapours, or dry exhalations, ascend from the earth, water, minerals, vegetables, animals, &c. in a word, wherever substances are elevated by the celestial, or subterranean heat, and thence diffused into more subtle, and consist of those exceedingly minute atoms, the magnetical effluvia of the earth, with other innumerable particles sent from the bodies of the celestial luminaries, and causing, by their impulse, the idea of light in us. The third sort is its characteristic and essential property, we mean permanently elastic parts. *History of Air.*

total concretion: For there is still fire remaining; and even the smallest fire will produce motion, which is inconsistent with firmness.

*As much fire in
air as in spirit
of wine.*

Air, therefore, is always warm, or has fire; which conclusion I had an opportunity last year of confirming, by a great number of experiments: in the course whereof, I made appear that the degree of fire in air is the same with that in alcohol of wine.

This fire, equably dispersed thro' the atmosphere, tho' incapable of being totally separated from the same, may yet be diminished to any degree at pleasure.

*Air varied by
the varieties in
the heavenly bo-
dies.*

And since the air lies open to the influxes of the sun and stars, it must be various, as it is variously affected thereby*.

Air, we have observed, is kept moving and fluid by means of the fire, and in proportion thereto: for no degree of fire remains constant, but is perpetually either increasing or diminishing.

* Besides the alterations in respect of heat and cold, drought and moisture, to which our atmosphere is liable from the heavenly bodies; very great philosophers have suspected that there may be other more immediate and specific ones. Sir I. Newton supposes, that the vapour which makes the tail of comets, coming to be exceedingly rarified and agitated in their approach toward the sun, may be driven and diffused thence thro' the heavenly spaces, and so come to be attracted by the several planets within whose spheres of activity it chanceth to be thrown. Thus mixing with their atmospheres, says he, it may afford them a fresh supply of water, to defray the continual expences thereof in vegetation, putrefaction, &c. He adds, that he suspects the finest, purest, and best part of our air, that, in effect, whereby life is sustained, to be principally derived from the Comets. *Phil. Nat. Princ. Math. l. 3.*

Mr. Boyle suggests, that even the sun, and other celestial bodies, may have influences here below distinct from their heat and light; and that the subtile effluvia thereof, may reach as far as our atmosphere, and mix therewith. Every planet, says he, has its own proper light, distinct from that of the others; which is either a bare quality, on which supposition its utmost use and design is only to illuminate: or else all light is attended with some peculiar virtue, or tincture; in which case every light must have its peculiar property, tincture and colour, its own specific virtue and power; in which the planets all differ from each other. Thus, adds he, the sun not only shines on all the planets, but, by his genial warmth, calls

forth, excites, and raises the motions, properties, and powers, peculiar to them. Whence, according to the angle they make with that grand luminary, and the degree wherein they are enlightened, either by its direct or oblique rays, in a near or remote situation in respect of the earth; the effects of the powers, virtues, and tinctures proper to each, must be more or less perceived by us. *Hist. of Air.*

—As the other planets, so also our earth, is not only enlightened, warmed, cherished, and made fruitful by the influence of the sun; but it hath, moreover, its proper magnetical, planetary force, awakened, fermented, excited, and agitated thereby; which it sends back with the reflected light of that luminary. By this means also, the seminal dispositions, odours and ferments, lodged in particular regions and parts hereof, emit and diffuse thro' the air either their kindly and grateful, or malignant, congealing, and putrefying qualities. Hence, tho' the temper, disposition, and general qualities of the air, may be assigned, according to the motions, influences, and aspects of several superior planets; yet the particular healthfulness and unhealthfulness of places; the bad dispositions of the air, whether in the evenings, nights or mornings; in some places more than others; excessive moisture, great winds, droughts, or seasons peculiar to a country; should chiefly be ascribed to those odours, vapours and exhalations, that by the action of the sun, or other planets, are forced from their particular seats in the planets themselves, into the open air. *Id. Ibid.*

If, now, this fire in the air be only acted on, or impelled in parallel lines, it remains insensible therein; as is evident in high mountains, where, tho the sun shines with all his vigour, yet the cold is extreme: but, if the fire be reflected, the air then grows sensibly warm. 'Tis not, therefore, the action of the sun that occasions warmth; but the reflection of the fire from solid bodies. And hence the warmth is usually the most felt in valleys.

The air, therefore, receives various degrees of fire, 1°, In respect of the sun, as he emits his rays, either obliquely, or perpendicularly. 2°, In respect of the earth, as it either absorbs the rays it receives, or reflects them.

'Tis this fire contained in air, that seems chiefly to move those foreign, grosser corpuscles wherewith the atmosphere is replenished by the exhalations sent from terrestrial bodies; as is found by those who travel the higher mountains, and who find their senses of smelling and tasting greatly diminished, and almost lost. Wine is there found as insipid as water: which, no doubt, is owing to a want of the due pressure and application of the particles of the liquor to the papillæ of the tongue, &c. The like is observed in very severe winter weather, when the sense of tasting is always diminished proportionably to the degree of cold.

Exhalations in AIR, which render it an universal chaos or conflux of all bodies.

II. **I**N respect of *Exhalations*, air may be said to be a general collection of all kinds of bodies*: for there are none but what fire will render volatile, and disperse into air. Even salts, sulphurs, and stones; nay, and gold it self, tho the heaviest and most fixed of bodies, we have already observed, are convertible into vapour by a large burning-glass, and carried on high.

Those floating particles, thus raised from terrestrial bodies, are moved and agitated by the fiery particles divers ways; whence arise tremors and concussions in the air; which being communicated to bodies that lie in their way, produce innumerable effects†. So, in places where great fires, combustions, conflagrations, &c. are; volatile salts of all

* This Mr. Boyle long ago noted: 'Our atmosphere, says he, is a compound or aggregate of effluvia from such different bodies, as, tho they all agree in constituting, by their minuteness and various motions, one great mass of fluid matter, yet, perhaps, there is not a more heterogeneous body in the world.' *Suspicion of Hid. Qual. in the Air.*
† 'Tho the chief of the heterogeneous effluvia, that endue the air with secret qualities, may, probably, proceed from beneath the surface of the earth, and from the celestial bodies; yet at some times, and in some places, the air may derive multitudes of efficacious particles from its own operations; acting as a fluid substance upon the vast number and variety of bodies, which are immediately exposed to it.' Boyle, *Hid. Qual. in Air.*

Theory of CHEMISTRY.

sorts are copiously discharged into the air, there agitated by the fire, and diffused thro' the whole atmosphere. And hence arise various actions on bodies: thus, near copper and iron furnaces, forges, &c. innumerable effects are produced by the fire's agitating the grosser corpuscles in the air, impelling one against another, breaking, comminuting, &c.

Of the matters thus raised into the atmosphere; those coming from fluid bodies are properly called *Vapours*; and those from solid or dry ones, *Exhalations*.

Of these, the variety is almost infinite; and there is scarce any body in nature that can be excepted from the number: for gold sticks close to sulphur in the mines, and is raised with it. And, with the other metals, a like inflammable, arsenical sulphur is usually found intermixed; which being agitated by fire, readily carries them off: And the other fossils, as coals, marcasites, &c. rise with still more ease. So also, all sorts of waters, spirits, oils, acid, alkaline, inflammable, compound, &c. must be ever floating, in abundance, in the air; as follows from the continual distillations, &c. made thereof. Earths, we add, are many of them easily volatilized, and made to float in air; for all, even the subtlest, oils, yield a considerable quantity of earth at the second distillation; so that the earth must float with the oil. What then can be excepted? Nothing.

The cause of this volatility, and ascent, is the fire; without which, all things would fall immediately down toward the centre of the earth, and remain in eternal rest. Thus, if the air be full of vapours, and cold succeed; those vapours before dispersed, are congregated and condensed into clouds; and thus fall back again in form of water. So when water boils, we see a vapour ascend; and no body doubts but that 'tis fire is the cause of that elevation, as well as of the other motions of the water: whether this fire be originally in the air, or whether it be determined thither from the celestial bodies, or whether it come from subterraneous places.

Air, then, replete with such a variety of exhalations, may be looked on as a general chaos. And,

The matter of infinite numbers of animals of all sorts in the air.

1^o, The parts of all animals are found therein: for any animal, being exposed to the air, will exhale, or dissipate; even tho the wind does not blow; leaving the bones alone; which yet, in a few years, will themselves exhale. So that what, before, made the animal, v. g. a man, a horse, dog, or the like, is now all in the air, both fluid parts and solid*.

2^o, The

* And here the excrementitious parts must make no small figure: My Lord Sandwich, and two Gentlemen of his retinue, assured Mr. Boyle, 'That the common report, as to there being no necessary houses at Madrid, was true; and that tho they always make a jakes of their streets over night, 'tis not easily discoverable by the scent the next morning. Madrid, however, his Lordship said, had a more offensive scent than any city he knew: but they all agreed, that the place wherein the ambassador's family constantly

2°, The parts of all vegetables are also there: for, take any plant, and ^{Of all sorts of vegetables.} putrify it; and it all readily becomes volatile; except the earth, which in time evaporates like the rest.

And, 3°, the parts of all fossils: for all salts, for instance, are carried off by ^{Of all sorts of} a vehement fire, into the air †; and the same holds of sulphurs, stones, &c. ^{fossils.} Nay, and gold it self, as has been divers times observed, is readily sent, by a large burning-glass, the same way.

The atmosphere, therefore, may be looked on as an universal receptacle, or chemical vessel, wherein all the bodies in nature actually float.

And hence we are enabled to account for many of the effects of ^{Hence various effects of air.} air: About mines, deep caverns, &c. there are frequently found copious fumes, and exhalations continually issuing out, which in a moment's time destroy any animal that comes within their reach; so much as the very insects; flies themselves not escaping. These places the antients called *Ge-benna*, *Spelunca*, and *Averni*, from *a* and *ospro*, a bird; intimating thereby that birds could not fly over them but dropped down dead. Such, in Italy, is the *Grotta dei Cani*; a dog held over which, but a single mo-^{Grotta dei Cani.} ment, expires; tho, if instantly thrown into cold water, he recovers, and comes to life again. On the contrary, in a certain place in Poland, where the inhabitants are said to attain to an hundred years of age, the air is always clear, and the neighbouring lakes and springs afford a salutary vapour*. Add, that in Sicily there are divers places now inhabited, which were antiently perfectly uninhabitable.

* constantly made water, had no scent of urine; and that they frequently observed, both the dogs and cats, which lay dead in the streets, afforded no offensive smell. Id. Hist. of Air.

† One principal sort of these effluvia in the atmosphere, I take to be saline, which float varioussly among the rest in that vast ocean; for they seem not to be equally mixed therein, but are to be found of different kinds, in different quantities and places, at different seasons. The arguments which shew that subterraneous effluvia in general, ascend plentifully into the air, prove the same of saline ones in particular; since it has been demonstrated, that immense quantities of common, nitrous, aluminous, vitriolic, and perhaps other salts, rise among the various exhalations of the terraqueous globe. Nor is this the only means whereby the air may be impregnated with saline particles; for the action of the sun upon the superficial parts of the earth and sea, will, alone, supply that fluid with swarms of them. And the quantity hereof may be greatly increased in several places by such vulcano's as have open

vents, by the smoke of the common culinary fires, &c. Boyle's Hist. of Air.

The air of some places may, besides the simple salts already mentioned, contain some compound ones; it being shewn, that particular saline spirits may meet and join together therein; as also that two liquors may be so ordered, that one of them shall never, of it self, afford any thing in a dry form, yet its spirituous effluvia meeting with those of the æther, produce a dry, volatile and saline body; which the mixture of the liquors themselves would not. Ibid.

* In an express treatise on the wholesomeness and unwholesomeness of the air, Mr. Boyle makes appear, that it depends principally on the impregnation the air receives from subterranean effluvia, a cause generally overlook'd by physicians; of which he distinguishes divers kinds, viz. ordinary, which are almost constantly sending up; extraordinary, which rise but at certain times. These, again, if they come at stated seasons, he calls periodical; if uncertainly, fortuitous, or irregular.

In the general, tho the wholesomeness of the air in some places may be chiefly due to the wholesome expirations of subterranean bodies; yet is the air depraved in far more places than it is improved, by being impregnated with mineral expirations. Indeed, among the minerals known to us, there are many more noxious than wholesome; and the power of the former to do mischief, is more efficacious than of the latter to do good; as we may guess by the small benefit men receive in point of health, by the effluvia of any mineral, or other known fossil, in comparison of the great and sudden damage that is often done by the expirations of orpiment, sandarack, and white arsenic.

Among the various sorts of particles where-with the atmosphere is replete, some, he shews, may be so small and solid, or so conveniently shaped, as to enter many of the numerous orifices of the minute glandules of the skin, or at other pores thereof. Thus, tho neither paper, nor a bladder, be pervious to the elastic parts of the air; yet may either of them be easily penetrated by other corpuscles of the atmosphere: and that excellent author has prepared a dry body, which being inclosed in either, would, without wetting or discolouring, or any way sensibly altering them, pass in a trice thro' the pores thereof, in such plenty as to exert a manifest operation on bodies placed at some distance therefrom.

This is confirmed from the sudden check almost every summer given to the plague at *Grand Cairo*: for, since morbid causes operate more effectually than curative ones, it seems more than probable, that exhalations ascending from under ground, may produce pestilential fevers, and the plague it self; since the corpuscles which impregnate the *Egyptian* air upon the swelling of the *Nile*, put a speedy stop not only to the contagion, but to the malignity of the plague, assisted even by the summer's heat, which there is excessive.

'Tis very probable, that most of the diseases, which even most physicians call *new*, are caused, either principally or secondarily, by subterranean steams.

Indeed there may be noxious minerals in a country, without being often able to produce pestilences: they may lie in beds so deep, that even a small earthquake shall not reach so far downwards, as to affect them; tho a more violent shock may. And hence we may account for the plague's raging in some parts of *Africa*, once in thirty, or once in a hundred years; since there may be periodical paroxysms, or

grand and vehement commotions, in subterranean parts, tho not yet observed in them. A late judicious *French* historian records, that a very pernicious disease, of the nature of a cholic, reigned in *France* every tenth year, for seventy years together.

Mezeray relates, 'That the great plague which happened in *France* in the year 1346, and which was so contagious, that scarce a village, or even an house, escaped uninfected; began, two years before, in the kingdom of *Cathay*, by a vapour most horribly fetid, and breaking out of the earth, like a kind of subterranean fire; which consumed and devoured above two hundred leagues of that country, even to the very trees and stones; and infected the air in a wonderful manner.' He adds, 'that from *Cathay* it passed into *Asia* and *Greece*, thence into *Africa*, and afterwards into *Europe*, which it ransacked throughout.' *Hist. de France.*

And not only plagues, but most new, contagious, and epidemical diseases, Mr. *Boyle* takes to arise from subterraneous causes. He instances a great cold, which, in one day or two, invaded multitudes in the same city, with violent and fatal symptoms; when yet, he could see no room to judge, that the bare coldness of the air could so suddenly produce a disease so epidemical and hurtful; and it appeared more probable that the cause came from under ground, because it began with a very troublesome fog.

Peculiar kinds of venomous exhalations, 'tis probable, may sometimes be emitted; especially after earthquakes; and thus occasion mortal diseases in animals of one kind, and not of another; and in this or that place, and not elsewhere. *Fernelius* gives us an account of a plague or murrain in 1514, which invaded none but cats. *Dionysius Halicarnassensis* mentions a plague which attacked none but maids; and that which raged in the time of *Gentilius* killed scarce any women; and very few but lusty men. *Boterus* mentions another great plague which assaulted none but the younger sort; and we have instances of the same kind of a later standing. *Cardan* speaks of a plague at *Basil*, with which the *Switzers*, and not the *Italians*, *Germans*, or *French*, were infected; and *Joh. Uttenhovius* takes notice of a cruel plague at *Copenhagen*; which, tho it raged among the *Danes*, spared the *Germans*, *Dutch*, and *English*, who went with all freedom, and without the least danger, to the houses of the infected.

From these exhalations, the air in different places becomes very different*: thus where there are mines of sulphur, as in Carniola, ^{Whence the difference of air in different places,} † *Campania*, &c. the air is frequently very pernicious. Add, that the effluvia of animals have their effect on the air; as is evident in the case of contagious diseases, plagues, murrains, and other mortalities which are spread by the air. And the like is observed of plants ||.

The air, again, becomes different according to the season of the year: ^{Indifferent seasons.} for in winter, the earth, being bound up with cold, scarce sends any exhalations at all; and yet the subterranean fire is all the while agitating, and preparing particles of all kinds, to be set at liberty from their subterranean holds, by the warmth of the ensuing spring, and discharged into the common receiver, the air. And hence the difference between the vernal and autumnal air; for if you sow the same seed in the same ground, in spring and in autumn, different plants will arise; even tho the degree of heat were the same in both cases. And for this reason it is, that many chemists, to get the greater quantity of spirit from corns, use to steep them in rain-water gathered in the spring.

* In places abounding with *Marcasites*, says Mr. Boyle, 'there is a fretting viriolic salt largely dispersed thro' the air, which has been observed to rot the hangings of rooms, and other furniture; and to lie upon the surface of the ground in a whitish efflorescence, after the sun had heated the moist and blackish mould wherein it lay.' Boyle's *Hist. of Air*.

Besides these saline substances of a determinate species, there are possibly, at certain times and places, other corpuscles in the air of a saline nature, but not reducible to any particular kind, which we therefore call *anonymous*. We have observed in old glass windows, belonging to high and antient buildings, some panes corroded, as if they had been worm-eaten; which seems to argue, that sharp and fretting particles had been carried thither by winds, whereto that glass was exposed; tho none of the salts before-mentioned have the faculty of corroding common glass. *Id. ibid.*

† The many saline effluvia that rise with the other subterraneous steams, cannot, all of them, be well suppos'd of a simple and uncompounded nature. A very intelligent acquaintance of mine, who visited a vulcano in *America*, told me, that before he came near enough to the fire, to be very sensible of its heat, the skin of his face was so corroded, and the colour of his hair changed, by the exhalations, as to prevent his nearer approach thereto.' *Id. Hist. of Air*.

'At *Fahlun* in *Sweden*, noted for one of

the best copper mines of that kingdom, the mineral exhalations affect the air so, that their silver coin is frequently discoloured, and sometimes turned black thereby; tho close tied up in several purses, and locked up in strong chests. The same effluvia manifestly affect brass, and to such a degree, that there is no possibility of keeping their utensils of this kind tolerably clean.' *Id. ibid.*

'A virtuoso, who possessed a piece of ground wherein ran several veins of different metals and minerals, told me he had frequently seen pillars, as it were, of fumes, ascending thence like smoke; some whereof had no scent, some an ill one, and some again a good one; tho the latter happened but seldom.' *Id. ibid.*

|| 'A very ingenious physician told me, he learned upon the island *Ternate*, that the *Dutch* having agreed with the king, to sell almost all the clove-trees that grew there, in order to raise the value of their spice; such a change in the temper of the air happened thereupon, as shewed the exhalations which the blossoms, when dried, afford the cloves to be very wholesome; for soon after these fragrant trees were cut down, the whole island became exceedingly sickly; which my relator imputed to the corrosive and noxious steams of a vulcano there, the ill effects whereof were formerly prevented by the aromatic effluvia of those spicy blossoms.' Boyle *ubi supra*.

And

And thus we see the reason why in some countries, where the winter is severer than ordinary, the spring is more than ordinary fruitful: for here the exhalations, being pent up a long time, are discharged in the greater quantity, when the sun makes 'em a passage; whereas, under a feebler cold, the efflux would have been continual, and consequently no great stock reserved for the next occasion.

From the entrance of the spring till autumn, the evaporation is constant: but then it begins to fail; and in the winter ceases, to lay up fresh matter for the coming season.

*Whence severe
winters produce
plentiful har-
vests.*

Thus it is, that frosty winters, by congealing the waters, and covering the earth with a crust, and thus imprisoning the exhalations; make a fruitful summer: for this is no check upon the subterraneous fire, which still continues its office; the frost never reaching above two foot under ground. So that if you dig to that depth, in winter, the earth will always be found to smother very plentifully.

This vaporous matter, then, being at length received into the atmosphere, is returned again in form of rain, the sure fore-runner of a cheerful crop.

When the cold is very considerable in summer, thunder and lightning arise; which contribute to the loosening and setting at liberty the remaining vapours, deep inclosed under ground: and when the sun's force begins to fail, they must of course return in showers, &c.

While the sun is returning from the winter's solstice to the summer's, his rays darting on us still more and more perpendicularly, the matter of the earth is more and more relaxed, softened, and putrified; till he arrives at the tropic, where his heat and force is at the height. And then, with the force of a chemical agent, he converts or resolves every thing near the surface of the earth into its principles, water, sulphur, salt and oil, which are easily raised into the atmosphere.

As the sun retires, the cold succeeds: and thus, the diversity of seasons of the year, depends on a change in the face of the crust of the earth, the presence of the air, and the sun's course*.

And hence we conceive the nature of meteors, which are all either collections of such vapours, and exhalations, or dispersions thereof. Collections of vapours make clouds; which being further and further condensed, turn to snow, rain, or hail. The subtiler oils, we have noted, are always

* Mr. Boyle suggests farther variations in the air, accruing from the diversity of heat and cold: 'The air, he observes, being a fluid as well as water, and impregnated with salts of different kinds, 'tis not improbable, that what happens in water, impregnated with such salts, may also happen in the air. Two proper quantities, of different salts, being dissolved in hot water, they floated undistinguishably therein, and retained a capacity to act in conjunction upon several occasions; yet when

' the liquor became cold, the saline particles of one kind being no longer agitated by a due degree of heat, shot into crystals; and losing their fluidity and motion, visibly separated themselves from the other, which still continued fluid in the liquor, and capable of acting separately. Hence it seems probable, that coldness and heat may, for a time, greatly alter the qualities of the air, with regard to the bodies and health of mankind. *Ibid.*

rising into the air: now two clouds partly formed of such oils, hap-^{Whence thun-} pening to meet and mix; by the attrition, the oil frequently takes fire; ^{der.} and hence thunder, lightning †, and other fiery phenomena: which may be further promoted by the disposition of the clouds to favour the excitation.

And hence arise great and sudden alterations in the air; insomuch, that it shall now be intensely hot, and raise the spirit, perhaps, to eighty eight degrees: and yet, after a clap of thunder, with a shower, it shall fall again, in a few minutes, no less than twenty or thirty degrees.

Ice may be, and is, formed even in the heavens, from the intense cold that frequently prevails there; and the sun's ray's passing duly thro' ice, have their force considerably increased; as we see in burning-glasses made of ice. And hence may our degree of heat be liable to be greatly heightened; as, accordingly, we observe, that when our atmosphere is replete with clouds, provided they be not gross enough to intercept the rays; our heat is then most intense and sultry. 'Tis known that none of these clouds are above an *English* mile high*; and hence on very high mountains, the warmth is inconsiderable. In effect, our heat depends ^{On what the heat of our weather chiefly depends.} more on the circumstances of the clouds, and the bodies beneath them, than on all that is above them; taking sun, moon, stars, and all. 'Tis impossible therefore to pronounce what the degree of heat will be in any given place, at any time; even tho we knew ever so well the places and positions of the sun and planets, with respect to us: since it depends so much on other variable things, no ways capable of being ascertained.

These meteors too have their effects on the air: thus thunder is ^{Effects of thunder.} known to produce new fermentations of liquors, &c.

To these may be added another cause, which varies the condition of the ^{Earthquakes.} air, viz. earthquakes: for, the fire perpetually burning under ground, has its spiracles or vent-holes; which happening by any means to be stopped up, it produces violent tremors and shakes, till it has opened it self a new passage, where none was before. And if the matter discharged hereat ||, be

† Effects of the like kind have even been observed, where so many circumstances have not concurred: A *Neapolitan* nobleman acquainted Mr. Boyle, that during his stay at a country-house near *Naples*, he used frequently to ride upon a very sulphureous soil, where, if his horse trod pretty hard, a great crackling noise would arise, which, to a stranger, might have seem'd surprizing; and dusty sulphureous fumes would be raised, which seem'd ready to take fire, as sometimes he thought they actually did; and having caused some turfs to be cut out of this ground, and laid together in a heap, he could, in the night-time, sometimes observe the effluvia thence arising to kindle in the air.

* ' An excellent astronomer of my acquaintance, who frequently took the height of the clouds, very rarely found any even of the white ones, in fair weather, to be more than three quarters of a mile, and seldom above half a mile, from the surface of the earth.' Boyle's *Hist. of Air*.

|| ' 'Tis well known, that about mount *Vesuvius*, the exhalations are of so saline and sulphureous a nature, that they adhere to the orifices of its vents, like flowers of sulphur. And I have a stone brought me from the same volcano, with a white salt in its cavities; which, upon examination, proved a kin to sal-amoniac, and easily soluble in water; one part being very volatile, and the other remaining

Effluvia of
mines.

be of any poisonous quality; the air, being replete therewith, becomes of course unwholesome, contagious, and frequently deadly.

This eruption of pestilential vapours, is no where more apparent than at the *Cape of Good-hope*; where the mines, as soon as opened, emit such horrible fumes from the arsenic, which is a constant attendant on gold, that no animal can live near them; so that endless treasures may there remain for ever useless*.

The same cause, here, likewise operates; in that by such succussions of the earth, conversions are made of dry land into lakes or seas; of sound wholesome places, into rotten putrid ones. So also, where ships formerly sailed, we now plough a dry and solid soil.

Difference of
air at different
degrees of depth.

The height or depth of air, makes a yet further considerable alteration therein: for the exhalations are few of them able to ascend above the tops of mountains †; as appears from those plagues where the inhabitants

• maining somewhat fixt; whence it seems
• very probable, that salt was compounded in
• the bowels of the vulcano; great quantities
• thereof having, as I am evidently informed,
• been cast up in the fiery eruptions; and
• therefore, since I found it sublimable, it
• might, by that means, be largely dispersed
• thro' the air.' Boyle, *ubi supra*.

• Eighteen years ago, a terrible noise began at
• the port of *Santorini*; reaching even to *Chio*,
• distant therefrom above two hundred miles;
• which was supposed to proceed from the *Vene-*
• *tians* fighting with the *Turks*: but at length it
• was found to be caused by a fire underneath
• the port above-mentioned, which there cast
• up, from the bottom of the sea, quantities
• of pumice-stones, with a force and report
• as great as if they had been severally dis-
• charged from a cannon. The air of *Santo-*
• *rini* was by this means so infected, that abun-
• dance of people were killed, and many lost
• their sight thereby; tho they recovered it in
• a few days afterwards. This infection spread
• it self as far as the preceding noise had
• reached; for even at *Chio* and *Smyrna*, all
• the coin was changed red, both that in the
• pocket and that locked up in chests; and the
• same happened to the silver chalices in the
• churches. The infection, however, vanished
• in a few days time, and the silver recover'd
• its native colour.' *Voyage de Levant*.

In the year 1660, in the kingdom of *Naples*, after an eruption of *Vesuvius*, strange
crosses appeared on linen that had lain open
to the air. They were extremely numerous
in several parts of the kingdom of *Naples*;
and the jesuit, who sent the relation to
Kirsber, says, that he himself found thirty in

one altar-cloth; fifteen upon the shift-sleeve
of a woman; and eight in a boy's band. Their
colour and magnitude were also very unequal,
and their figure different; they would not
wash out with simple water, but required soap.
These were found, not only upon linen gar-
ments exposed to the air, but upon some of
those that were kept up in locked chests.

* What effect the neighbourhood of mines
have, appears from Mr. Boyle: A famous
chemist, who lived in a country abounding
with mines of vitriol, assured him, that he
had found the oaks growing over them to be
remarkably more solid and heavy, than those
trees elsewhere are; upon which Mr. Boyle
observes, that the parts of some minerals are
capable of insinuating themselves very plem-
fully into the pores of growing vegetables,
without being really subdued by what the phi-
losophers call the concocting faculty of the
plant; but instead of being assimilated by the
vegetable, retain their own mineral nature;
and upon the recess, or evaporation of the
juice that served them for a vehicle, some-
times discover themselves to the naked eye.
He adds, that he has seen a piece of a vine,
that grew not far from *Paris*, which being
broken, a multitude of the internal pores
of the root, and a part of the trunk also,
appeared to be stuffed with corpuscles of a
marcasitical nature, as was plain by their co-
lour, their shining lustre, and their weight.
Causes of wholesomeness, &c. of the air.

† 'On one side of the mountains of *Bo-*
varia 'tis winter, and on the other (summer)
' at the same time; so that while this side is
' parched with heat, that lies buried in snow.'
Balbin. Hist. Bohem. p. 55.

of one side of a mountain have all perished, yet those on the other side all the while remained in perfect health. Now still, the lower the place, the closer, denser, and heavier the air; till, at length, you arrive at a depth where fire goes out: so that the miners, who go very deep, to remedy this inconvenience, are forced to have recourse to an artificial wind; raised by the fall of waters, to do the office of the other air*.

The air may likewise undergo some alterations by means of its motion: *Effect of winds*, thus a brisk wind lessens the pressure of the incumbent atmosphere; by which means the subterraneous air may be enabled to raise the crust of earth, or occasion a shuddering thereof. And hence that observation of Mr. *Hauksby*, that the barometer sinks very notably, when the wind is raised, or the air agitated, about the same.

Now, considering the air as such a chaos or assemblage of all kinds of bodies, and a chaos so extremely liable to change; it must needs have a great influence on chemical operations, and occasion notable alterations in the same: thus there is scarce any procuring of oil of sulphur, *per campanam*, in a clear air; its parts being then so extremely ready to fly off: but in a thick cloudy air, it yields oil in abundance. And thus salts melt the easiest in a cloudy air; and when melted, act the most forcibly: and all separations succeed the best in such weather. *Effect of air on chemical operations. Oil of sulphur, &c. when best procured.*

The success of chemical operations, therefore, has a near dependence on the air; and the same operation performed at different places, or times, when the air is differently impregnated, &c. may well have a different effect. Thus if salt of tartar be exposed to the air, in a place where any acid spirit, as vinegar, is floating in the air, as in the shops where vinegar is sold; it will draw the vinegar to it self, and by that means lose its former qualities, and, of fixed, become volatile: but in places where there is no acid, it dissolves into an extremely sharp oil †. *Different effects of the same operation.*

And

* Nor must drought and moisture be denied their share in varying the state of the atmosphere: At *Guinea*, the heat, with the moisture of the air, are said to be so favourable to putrefaction, that the finest white sugar shall sometimes be full of maggots; and all their drugs, plaisters, &c. quite lose their virtue; and some of them grow verminous. 'Tis added, that in the island of *Jago*, they are obliged to expose their sweetmeats to the heat of the sun; and thereby exhale the moisture they contracted in the night, which would otherwise have caused them to putrefy. *Boyle's Hift. of Air.*

The string of a viol has been observed to increase in the acuteness of its tone, by almost half a note, either a little before, or in rainy weather; and the same observer has

likewise found that putting false strings in his pocket for frets, they have been found true when he came to use them. *Id. ibid.*

‘ If some *Egyptian* earth be taken up
‘ near the river, and carefully preserved from
‘ the wet and waste, ’twill be found, if duly
‘ examined by the ballance, neither to increase
‘ nor diminish its weight till the 17th of *June*;
‘ when it will begin to grow heavier, and
‘ continue to do so as the river fills; whence
‘ they certainly know the state of the deluge,
‘ which doubtless proceeds from the moisture
‘ of the air.’ *Prosper. Alpinus, Joh. Vatro-
rot, &c. p. 69.*

† The air of particular places, as about great towns, &c. Mr. *Boyle* observes may probably abound with volatile salts, of a contrary nature to acids. That places deep under the

And thus the experiments made of salts, at *London*, where the air is plentifully impregnated with sulphur, exhaled from the sea-coal, are very different from those made on the same subjects in other parts of the kingdom, where wood, turf, &c. are the usual fuel*.

Effects of the various effluvia in the air, on chemical operations.

Those alterations in the air, wherewith our own bodies are found to be affected, affect chemical bodies, in a still more sensible manner: hence, as the air, in the laboratories of the chemists, is sometimes pregnant with acids, sometimes with alcalies, and sometimes with metallic fumes, their operations become strangely diversified.

And in general, the air, as it contains divers kinds of exhalations, has a wonderful effect towards promoting, stopping, or altering the actions of all bodies on each other; whence frequently arise very astonishing effects.

Of the fumes of new wine.

Thus, if pure, well-fermented wine, be carried into a place where the air is replenished with the fumes of new wine then fermenting; it will begin to ferment afresh. So we have seen salt of tartar swell, and as it were ferment, when carried into a place where spirits of nitre, vitriol, and sea-salt, were preparing; viz. by the contiguity of the acid particles floating in the air.

Plants in blossom, what effect they have.

It is matter of common observation among brewers, distillers of geneva, and vinegar-makers, That at the time when those plants use to be in flower, the respective juices ferment, and the operations succeed the best †.

Whence metals contract rust.

Metals exposed to the air, when well impregnated with such saline particles, soon corrode, and grow rusty; but the same in an air void of such particles, will remain a long time without damage: thus metalline instruments, and utensils, contract rust much sooner, and therefore need scouring much oftener, at *London*, where they are open to the acid or sulphurous exhalations of immense quantities of sea-coal, than

the ground may lodge such salts, seems not unlikely, from the experiment of an acquaintance of mine, who caused to be dug up, at the depth of several yards below the surface of the earth, a large quantity of a certain kind of clay, abounding in minerals; whence he obtained, by simple distillation, a considerable parcel of spirit of salt, greatly resembling those of urine or harts-horn. *Hist. of Air.*

* In places where much wood is burnt, numerous particles of volatile salt may easily be dispersed thro' the adjacent air; for wood-foot, which is only that small part of the smoke which adheres to the chimney-sides, affords a volatile, saline spirit in great plenty; and not readily, unless by the scent, distinguishable from that of urine or hartshorn.

Moreover, the putrefaction of animal substances, may supply the air with volatile salts,

since some putrefied urine will, without distillation, afford saline and spirituous parts, which, by their scent, &c. discover themselves to be volatile, even while swimming in their own large quantity of phlegm. And the like is observable in many vegetables. *Id. ibid.*

† Add, that stains caused by vegetable juices, are observed to be best taken out of linen at that time, when the several plants that afford them are in their prime. This one lady has experienced in new linen stained by the juice of quinces; and another in some discoloured by the juice of hops, which she thinks makes the worst of stains; but having tried in vain to fetch this out, she locked up the linen in a chest, till the season of hops came on, and then the spots vanished of themselves. *Id. ibid.*

in other parts, where there is less of the acidity *. And fermentation, which is easily raised and carried on in a place free of sulphur, is impracticable in places where sulphurous exhalations abound.

Add, that the singular success which the dyers of *Leyden* have, in dying wools of a scarlet colour, is, in all appearance, owing to no other cause, but the air which must be there impregnated with vitriolic, aluminous, and other saline exhalations, raised from the great quantities of those salts which the dyers daily empty out of their vessels into the waters of the city; for it is impossible the waters should be charged therewith, without the air's becoming a partaker: and hence, the same means, the very same ingredients, applied at *Amsterdam*, and else where, have not the same effect †.

It remains to be observed, tho it comes here somewhat out of place, that the air is every where in continual motion: for, in the stillest season, where there is no wind stirring, if you place your self in a darkened room, which only receives the day in at a little hole, capable of admitting a single ray; that ray dividing it self, and illuminating the whole length of the room, you will perceive every thing, all the external objects whose species are thus brought in, in motion; which can never be owing to our respiration: but to the external air which insinuating itself thro' the chinks of the edifice, moves that on the inside of the chamber. And hence the mercury in a very large, accurate barometer, is found to be continually vibrating, or leaping up and down, without ever remaining a moment quiet.

This perpetual motion of air is owing to the fire, which acts there on the true or proper air, by means of its native elasticity: but of this we shall treat anon; our business here is with air considered as a chaos.

* It does not appear that in-land countries abound considerably with corrosive salts; since the bars and casements of windows will not thereby be greatly impaired by rust, after they have endured the weather for twenty years; whence I conjecture, that the kind of salts whereby that dissolution is effected, proceeds from sea-vapours, or those raised by the burning of mineral coals. *Id. ibid.*

† Mr. Boyle proposes a method of determining what the particular species of salt is that predominates in the air of any place, or at any time. This, he thinks, may be done by a sort of magnets, or attractives, *i. e.* bodies fitted to detain and absorb, or at least likely to be affected by, the particular salts supposed chiefly to abound: For instance, if we suspect the air to be impregnated with nitre, lime, or the like bodies which imbibe

or retain such a saltiness; dyed cloths, or silks of such particular colours, which fade or tarnish with nitrous spirits, may be exposed thereto: where vitriolic effluvia are supposed predominant, proper preparations of sulphur may be suspended, to try whether they will acquire a blackness: In other places, guesses may be made, by spreading on the clean ground white linen cloth, well freed from soap or lye, and observing, after it has lain a considerable time, what discolouration it has suffered, and what saltiness it has imbibed; either from the ascending steams, or falling dews.

Or, you may find some one body capable of being affected by several aerial salts, in such different manners, as to discover which kind produced the respective changes. *Hist. of Airs*

The

The motion of the air, and consequently its force and effect, arise wholly from fire; and hence, the fire, by moving all the various kinds of particles which are in the air, performs infinite operations. In the extremest cold, the air scarce acts at all, but is contracted within itself; but when warmed, it expands again, and agitates other bodies: consequently, as the degrees of heat are infinite, so must the actions and effects of the air be. Add, that as this fire acts on all the corpuscles which are in the air, and these are infinite; 'tis evident all the actions thereof are indefinite.

Air, considered in it self, or that properly called AIR.

Proper air.

III. **B**ESIDES the fire and exhalations contained in the circumambient atmosphere, there is a third matter, which is what we properly mean by *air* *.

Its properties.

To define the nature of air, would be extremely difficult; in as much as its intimate affections are unknown to us. All we know, is, 1° That air is naturally an homogeneous similar body. 2° Fluid. 3° Heavy. 4° Elastic. 5° That it rarifies by fire, and contracts by cold. 6° That it is compressible by a weight laid thereon, and rises and restores it self upon a removal of the same. All which circumstances, should incline it to coalesce into a solid, were fire wanting.

Structure.

Mr. Boyle conceives the air to be a congeries of minute flocculi, all springy, expansile, and contractile; and takes it to derive its elastic

* Some of the later authors divide air into *transient* or apparent, and *permanent* or real: for that all which appears to be air, does not continue such, is evident hence, that if an eolipile of water be sufficiently heated, and suffered to expel the particles of air by its aqueous vapour; this will afterwards be forcibly driven out in a large quantity, like the blast of a pair of bellows, and occasion a sharp, whistling noise against the edge of a knife conveniently held there: yet such a vapour, tho whilst the motion lasts it resembles air, soon loses that resemblance; especially in the cold; and returns, by condensation, to its original water.

Mr. Boyle gives us several experiments and methods for the production of air; taking the word *production* for the obtaining a sensible quantity of that fluid from bodies wherein it did not before appear either at all, or in so great plenty; tho perhaps some of his experiments may argue a new and real production of air in the stricter sense of the word. *Hist. of Air.*

‘ Among the several ways of producing air, the fittest for practice seem to be fermentation, corrosion, and the dissolution of bodies, by the boiling of water and other liquors, by the mutual action of bodies upon one another, especially saline ones; and lastly, by analyzing and resolving certain substances.’ *Ibid.*

Sir I. Newton shews that gunpowder generates air; i. e. by explosion it goes off in a flaming smoke, or red-hot exhalation, consisting chiefly of the spirit of nitre rarified by the accension of the sulphur and charcoal, and driven off much after the manner of water out of an eolipyle; the volatile sulphur, at the same time, and the fixed body of nitre, joining with it, and increasing the effect. *Opticks*, p. 317.

‘ I have found that various, solid, and mineral bodies, unsuspected of elasticity, being plunged in corrosive unelastical menstrua, will, upon a proper comminution of their parts, afford, in the conflict, a considerable quantity of permanently elastic air.’ Boyle, *ubi supra*.

force

force from its structure, or the form of these floccules; which he resembles to fleeces of wool †.

Sir I. Newton, without concerning himself as to the figure of the particles of air, considers its effects alone; and these aerial particles, he observes, in approaching nearer each other, exert certain new powers whereby they mutually endeavour to recede, or fly from each other: so that the further they are a-part, the less does this force act; and the nearer, the stronger *.

Either hypothesis may be sufficient: but we add, that the former assumes, or takes the most for granted; since it supposes the air to be fleecy; whereas, in the latter, the particles of the air may be of any figure at pleasure, provided they have but the *vis recedendi*. For our own parts, we confess we don't know what air is.

That air is a *body*, and *fluid*, no body will call in question, after what has been shewn above. And hence it is always in motion, and always moving other bodies; and no surface of any liquor that is contiguous to air can be at rest: which point we have proved more at length in our public lectures *de Aere*.

The *gravity* or heaviness of the air is easily proved: for the elements of all bodies, are as heavy as the elements of gold; and the variety of bodies in point of weight, arises only from the particular surface which those particles acquire, in the contexture. Thus, if you beat gold into

Repelling force
in their.

Fluidity of air.

Gravity.

† Various hypotheses may be framed relating to the structure of these particles of air. They might be resembled to the springs of watches, coiled up and endeavouring to restore themselves; to wools, which being compressed, have an elastic force; to slender wires, of different substances, consistences, lengths and thickness; in greater curls or less; near to or remote from each other, &c. yet all continuing springy, expansible and compressible. Lastly, they may also be compared to the thin shavings of different kinds of wood, various in their lengths, breadth, and thickness. Boyle, *ubi supra*.

* The instance of air and vapours, which seem to discover some such repelling power, that illustrious author brings as an argument of the same powers being found in other bodies:—'The particles emitted or shaken off from bodies by heat or fermentation, says he, so soon as they are beyond the reach of the attraction of the body, recede from it, and also from one another, with great strength; and keep at a distance; so, as sometimes to take above a million of times more space than they did before, in the form of a dense body: which vast contraction and expansion seems unintelligible,

by feigning the particles of air to be springy and ramous, or rolled up like hoops; or by any other means than a repulsive power.

'The particles of fluids which do not cohere too strongly, and are of such smallness as renders them most susceptible of those agitations which keep liquors in a fluid; are most easily separated, and rarified into vapour; and, in the language of the chemists, are *volatile*: rarifying with an easy heat, and condensing with cold. But those which are grosser, and so less susceptible of agitation, cohere by a stronger attraction, and are not separated without stronger heat, or perhaps not without fermentation; and these last are the bodies which chemists call *fixed*; which being rarified by fermentation, become true permanent air; those particles receding from one another with the greatest force, and being most difficultly brought together, which, upon contact, cohere most strongly.

'And because the particles of permanent air are grosser, and arise from denser substances than those of vapours; thence it is that true air is more ponderous than vapour, and that a moist atmosphere is lighter than a dry one.' Opticks, p. 371, 372.

very

very thin plates, or leaves, it will swim in water, or even air; so that it does by no means appear, that the last particles of air are more porous than those of gold *.

*Use and effects
of its pressure.*

Now, the weight of the whole incumbent air, is such as enables it to sustain mercury in the Torricellian tube to the height of 28 inches; and water to that of 32 feet. Air therefore, may be considered as an universal operculum, or cover, which by its weight, keeps all terrestrial bodies down, and prevents their flying off. And hence, if this pressure of the air be much diminished in any place, a piece of earth may happen to be raised thereby, and thus an earth-quake be produced: for the air under ground, having, by this means, a less weight to sustain, will expand itself; the consequence of which must be a subversion of the incumbent earth.

In mixing bodies.

The air thus pressing, and keeping things under, after the manner of an embolus; does, of consequence, mix them with one another: as, in effect, there is no natural mixture made without air †.

*In determining
one body to act
on another.*

'Tis air, again, that determines the action of one body to another; for, to have one body act on another, 'tis necessary it be applied or pressed against it. All the volatile bodies in the atmosphere, may be conceived as fluids floating in another fluid; now, the lighter the fluid, wherein bodies swim, is, the deeper must the bodies descend: thus we find gold sink to the bottom of water; and wood falls downright in air: on the contrary, the heavier the fluid, the more will the body emerge above water. And thus the fluid retains the several sorts of bodies in their respective places.

Menstruum inactive in vacuo.

Now, we find, if a menstruum be applied in vacuo, it has no effect. Thus vinegar does not prey on copper, or iron, in the exhausted receiver; but as soon as the air is let in, it begins to act, and a calx or rust soon ensues. So, if you lay the point of a diamond on the surface of a polished glass, it will not cut; but press it strongly with the hand, and it has its effect. Thus in *Papin's digester*: a thick, strong cylindrical vessel being filled with water, or the like menstruum; and the bones of some animal, e.g. an aged ox, included therein; and lastly, the cover or lid firmly fixed and folded over, so as neither water nor

* This proof is *à priori*. But we have much more sensible demonstrations of the thing from experiment: thus the hand, applied so as to cover the orifice of a receiver, upon working the air-pump, and thus withdrawing the subjacent air, soon feels the load; so, exhausting the air from a thin, square glass receiver, the pressure of the incumbent air easily bursts it: again, two hollow segments of a sphere, exactly fitting each other, being exhausted of their air, and thus exposed to the pressure of the external air; will sustain a force of 140 pounds; supposing their diameters 3 inches,

ere they separate. To say no more, the rising of mercury in the barometer to the height of 28 inches, and of water in pumps, &c. to that of 32 feet, are incontestable proofs of the weight of the air. See the Writers of Hydrostatics, Boyle, Wolfius, S^r Gravesand, &c.
† 'The particles whereof air consists do not touch each other; their *vis repulsi* keeps them a-part: and the force wherewith they endeavour to recede, increases in the same ratio wherein the distance of the particles is diminished.' S^r Gravesand, *ibid*.

air may escape : upon applying this to the fire, as the heated air comes to expand, it has a prodigious effect ; grinding and dissolving, in the space of a few minutes, the firmest bones into a mere fluid ; and this by the sole pressure of the air against the water, and bones.

But we have said that the air is an *elastic* body : Now, elasticity is a *Elasticity of the* quality whereby a body yields to any external impression, by contracting *air.* it self into less compass ; and upon removing or diminishing the impressing power, returns to its former space or figure. By this quality it is, that air is distinguished from all the other bodies in the atmosphere ; neither fire nor exhalations appearing to be elastic, at least in any notable degree.

That there is such a quality in the air, is evident from innumerable *Proved.* experiments. We shall only mention one : In the first invented thermometer, some air is included in a hollow ball ; which, as the warmth or cold increases or diminishes, contracts or expands it self ; and by that means either drives the spirit lower, or lets it rise higher. And to the same elastic power it is owing, that air inclosed in glass vessels, at a time when it is much condensed, frequently bursts the vessels, when it afterwards comes to expand by a further degree of heat *.

This property is inseparable from air : so that it was an oversight in *An inseparable* Mr. Hawksby to conclude, that air might be compressed so long, till it *property.* lost its elastic power, and became incapable of expanding it self again : for this is never found, even tho air have been kept in continual forcible compression the space of many years. That air is elastic in all places, appears hence, that the air contained in a bladder, endeavours to expand it self on the tops of the highest mountains, as much as with us.

This, further, is very wonderful in air ; that it should be capable of *No limits to the* being extended, and contracted infinitely ; for by all the experiments we *compression and* have seen or heard of, it does not appear that there are any limits of its *dilatation of* *the air.*

* ' The elasticity of the air is as its density ; for this last is inversely as the space taken up by the air, and therefore as the force compressing the air, which is equal to that by which the air endeavours to expand itself ; but this force is its elasticity.' *Gravesande's Elem. Physf.*

' The air is loaded by the weight of the whole atmosphere, pressing every way, according to the nature of a liquid ; the force it exerts does no way depend upon the elasticity ; because, whether you suppose elasticity or not, that force which arises from the weight of the atmosphere, and is equal to it, can no way be changed : but, as the air is elastic, it is reduced to such a space by the weight of the atmosphere, as that the elasticity, which re-acts against the compressing weight, is equal to that weight. But the elasticity increases and diminishes as

' the distance of the particles diminishes or increases, and it is no matter whether the air be retained in a certain space by the weight of the atmosphere, or any other way ; for in either case, it will endeavour to expand it self with the same force, and press every way. Therefore if the air near the earth be included in any vessel, without altering its density, the pressure of the included air will be equal to the weight of the whole atmosphere. Thus we find mercury sustained to the same height by the elastic force of air included in a glass vessel no way communicating with the external air, as by the weight of the whole atmosphere.' *Id. Ibid.*

' The effects of the elasticity of the air are like those of its gravity ; and included air acts by elasticity, just as air not included, by its weight.' *Id. Ibid.*

compression, or expansion; but still, by the addition of a new weight; it will contract further; and by taking weight away, expand further †. And hence, as there is no end of its compressibility, there should be none of its pores or vacuities.

*Cold condenses
air.*

The colder air is, the less space it possesses, and *vice versa*; hence cooling and compressing have the same effect thereon; nay, and cold and compression keep pace with each other. The same holds of warming, and diminishing of weight; or heat and expansion, which go hand in hand.

Thus, tho the air in high places is colder than nearer the surface of the earth; as all who have travelled the highest mountains agree; consequently, the air there must contract it self more in proportion: yet must the air of the same places, considered as it is pressed with a less load of incumbent air, expand it self more *. And hence the barometrical experiments made on the tops of the highest mountains, are frequently very wavering and precarious.

*The rarefactive
force of heat,
proportional to
the degree of
condensation.*

Monsieur Amontons first discovered, that air, the more it is condensed, the more it will expand with the same degree of heat; consequently, the more it is condensed, the greater is its elasticity. Now the condensation is in the reciprocal ratio of the weights wherewith it is pressed; and hence, if the air be pressed in one place, or at one time, an hundred times as much as at another, its expansive force, in the latter case, will be an hundred times that of the former ||.

Effects,

† Dr. Halley asserts, in the *Philosophical Transactions*, that, from the experiments made at London, and by the academy del Cimento at Florence, it may be safely concluded, that no force is able to reduce air into eight hundred times less space than it naturally possesses on the surface of the earth. In answer to which, M. Amontons maintains that there is no fixing any bounds to its condensation at all; that greater weights will still bring it into less compass; that it is only elastic in virtue of the fiery particles it contains; and that it is impossible absolutely to drive out all the fire, and consequently to make a perfect condensation. *Mem. de l'Acad. Ann. 1703.*

* The rule of this dilatation is, that the spaces possessed by the air are always inversely as the forces whereby it is compressed.

|| On this principle, M. Amontons has a discourse to prove that the weight and spring of the air, with a moderate degree of warmth, may enable it to produce earthquakes, &c. According to the experiments of M. de la Hire, and M. Amontons, a column of air on the surface of the earth, 36 fathoms high, is equal in weight to 3 lines of mercury; and

it is found, that equal weights of air possess spaces reciprocally proportional to the weights wherewith they are pressed: The weight of air, therefore, which would fill the whole space possessed by the terrestrial globe, would be equal to a cylinder of mercury whose base is equal to the surface of the earth, and its height contains as many times 3 lines as the atmospherical space contains orbs equal in weight to that of the 36 fathoms whereof the experiment was made.

Hence, taking the densest of all bodies, e. g. Gold, whose gravity is about 14630 times greater than that of air in our orb, it is easy to compute, that this air would be reduced to the same density as gold by the pressure of a column of mercury 14630 times 28 inches high, i. e. 409640 inches; since the bulk of air, in that case, would be in the reciprocal ratio of the weights wherewith they are pressed: this 409640 inches, therefore, expresses the height at which the barometer must stand, where air would be as heavy as gold; and the number $2 \frac{51632}{4096640}$ lines, the thickness of which our column of 36 fathoms of air

Effects, or Powers, of Air.

THE first effect of air is, that by being heavy and fluid, it invests the whole earth, and presses all the bodies thereon, with a great force; equal to what they would sustain from a pressure of 29 inches depth of mercury, or 32 feet of water †. By this means it binds up, and restrains terrestrial bodies; and thus prevents *e. g.* the arterial vessels of plants, and animals, from being too much distended by their circulating juices ||; and thus also hinders the juices from escaping out of the same. This is felt very sensibly in such as climb the tallest mountains; who find, that the higher they go, the more languid, relaxed and diffused they grow; till at length, they fall into a spitting of blood, and other hæmorrhages; by reason the air does not bind up the vessels of the lungs enough. The same we observe, in animals inclosed in the receiver of an air-pump; for, upon exhausting the air, they swell, vomit, drivel, dung, urine, sweat, &c.

Air binds up, and keeps together the part of bodies.

would be reduced in the same place. Now, we know, that 409640 inches, or 43528 fathoms, is only the seventyfourth part of the semi-diameter of the earth: and when you are past that, whatever matters there be, they must be lighter than air. 'Tis not improbable, therefore, that the remaining sphere of 6451538 fathoms diameter, may be full of dense air, heavier by many degrees than the heaviest bodies among us.

Hence, again, as it is proved that the more air is compressed, the more does the same degree of fire increase the force of its spring, and render it capable of so much the greater effect; and that, for instance, the heat of boiling water increases this spring of our air beyond what it ordinarily is, by a quantity equal to one third of the weight wherewith it is pressed: we may infer, that a degree of heat which in our orb can only produce a moderate effect, may have a very violent one in such lower orb; and that as there may be many degrees of heat in nature beyond that of boiling-water, 'tis probable there may be some whose violence, thus assisted by the weight of the air, may be sufficient to tear asunder the solid globe. *Mem. de l'Acad. Ann. 1703.*

† The atmosphere, in its free state, may be considered as if it had once been water, covering the earth, to the height of 31 feet; but afterwards exceedingly rarified, expanded and converted into what we call air; which, tho in fact it possesses a larger

space, has not a greater weight than water of the height of 31 feet. Now 'tis easy to compute what quantity of water would every way surround the earth, to that height; which gives the whole weight of the air: for, since a cubic foot of water weighs 72 pounds, a prism thereof (to use that for the sector of a sphere) whose base is a foot square, and height 31 feet, will weigh 2232 pounds; and since the surface of the earth contains 3711.420000.000000 square feet, the product of these two sums, which is 8.283889.440000.000000 pounds, gives the quantity of water, and consequently the quantity of air required.' *Paschal. Traits de l'Equilibre des Liqueurs.*

Hence, when a column of quick-silver, thirty inches high, is sustained in the barometer; as it frequently happens; a column of air that presses upon an inch square near the surface of the earth, must weigh above fifteen Averdupoise pounds.' *Id. ibid.*

|| Thus the difference of the air in point of gravity may come to have a very considerable influence on the healths of men: 'When the air, says Mr. Boyle, grows of a sudden much lighter than usual, the spirituous and aerial particles plentifully lodged in the blood, will naturally swell that liquor; and so distend the greater vessels, and alter the manner of the circulation thro' the capillary veins and arteries: whence several changes may happen in the body.' *Hist. of Air.*

Mixes bodies.

2°, It mixes different bodies together; for in being fluid, heavy and elastic, it can never be at rest; so that wherever it is present, it is always acting on the surfaces of contiguous bodies: and hence arise various mixtures of fluid matters. This is apparent enough in many liquids, as oils and salts which mix readily in air; but taking that away, remain quietly in their state of separation.

Makes bodies act on one another.

3°, It determines the action of one body to another. Bodies, we observe, would not have any effect on each other in vacuo; and 'tis by means of gravity that the actions of bodies are ordinarily communicated. Without such gravity, all bodies would be indifferent as to any motion; so that 'tis by means of this quality that the air so much as touches us.

Fire on fuel.

One great circumstance on which the action of bodies depends, is the pressure of one body against another; which pressure is frequently the effect of some other heavy body, and more particularly the air: thus the fire which burns wood, immediately goes out, and its flame dissipates, upon taking the air away; by reason there is wanting something to press the particles of fire against those of the fuel, and prevent the too speedy diffusion of the flame*. And the same is observed in *aqua regia* and gold:

* We are extremely apt to be too precipitate in our conclusions: after having learnt a few of the properties of a body, we think we have got all, and impose it on our selves to account for all the phenomena and effects thereof, how various soever, from what we do know. Hence innumerable crude, constrained solutions. No body appears to have been more on his guard, in this respect, than Mr. Boyle: he saw abundance of effects from air, which did not appear to have any dependance on the known mechanical properties thereof; and on this view composed that excellent piece of *Suspensions about some hidden qualities of the Air*. 'The difficulty, says he, we find in keeping flame and fire alive, tho' but for a little time, without air, renders it suspicious, that there may be dispersed thro' the atmosphere, some odd substance, either of a solar, astral, or subterraneous nature; on account whereof, the air is so necessary to the subsistence of flame. And this necessity I have found to be more considerable, and less dependent upon the manifest attributes of the air, than is usually observed; for by trials purposely made, it has appeared that a small flame of a lamp, tho' fed perhaps with a subtle thin oil, would, in a large receiver, expire for want of air, in a far less time than one would believe. And it will not much lessen the difficulty to

alledge, that either the gross fuliginous smoke in a large vessel, stifled the flame; or that the pressure of the air is requisite to impel up the aliment into the wicks; for to obviate these objections, it may be observed, that the experiment holds of spirit of wine, which, in the open air, will burn quite away, without any sensible smoke; and this without any wick at all.

Again,—It seems surprizing what should be in the air, which enabling it to keep flame alive, does yet, by being consumed or removed, so suddenly render the air unfit to preserve flame. It should seem, by the sudden wasting or spoiling of this fine substance, whatever it be, that the bulk of it is but very small in proportion to the air it impregnates with its virtue; for after the extinction of the flame, the air in the receiver was not visibly altered, and, for ought I could perceive by several ways of judging, the air retained either all, or the greatest part of its elasticity, which I take to be its most genuine and distinguishing property. This undestroyed springyness of the air, with the necessity of fresh air to the life of hot animals, suggests a great suspicion of some vital substance, if I may so call it, diffused thro' the air, whether it be a volatile nitre, or rather some anonymous substance, sidereal or subterranean; tho' not improbably

improbably of kin to that which seems so necessary to the maintenance of other flames.' *Ibid.*

Instances of strange anonymous effects of the air, sufficient to countenance such suspicions, we have enough. To what occur in the course of this and the following chapter, we shall here add another, viz. the appearance or growth of some salts, in certain bodies, which afford them not at all; or nothing near in such plenty, or so soon, unless they be exposed to the air.

Mr. Boyle causing a solid marcasite, hard as stone, to be broken, that the internal and more shining parts might be exposed to the air; he found, that tho this was done in a room where a good fire was usually kept, so that the marcasite was not only sheltered from the rain, but kept in a dry air; yet after a while, there appeared on this glittering part, an efflorescence of a vitriolic nature. Afterwards meeting with a ponderous, dark-coloured mineral, which at the very first breaking discovered to the eye no appearance of any salt, nor so much as any shining marcasitical particles; he found, that a large quantity of these hard and heavy bodies being kept exposed to the air, even in a room that preserved them from rain, tho probably they had lain many ages intire under ground, in the hill where they were found; yet, in a few months, by the operation of the air upon them, were in a great part crumbled to a powder, exceeding rich in copperas. Nay, having laid up some of these stones in a room, where he constantly kept a fire, and in the drawer of a cabinet, which he did not often take out to give them fresh air, most of them were covered with a large efflorescence; which, by its conspicuous colour, between blue and green, by its taste and fitness to make in a trice an inky mixture with an infusion of galls, sufficiently manifested it self to be vitriol.

That the earth, or ore of alum, robbed of its salt, will in tract of time recover it, by being exposed to the air, we are assured by the experienced *Agricola*. And Mr. Boyle observes, that some kind of lime in old walls, and moist places, has, in time, gained a large efflorescence, very much of a nitrous nature; as he was convinced by having obtained salt-petre from it, upon barely dissolving it in common water, and evaporating the filtered solution.

It may seem doubtful, whether the salts appearing in the fore-mentioned cases are really

produced by the operation of the air workire, as an agent, or also concurring as an ingredient; or whether these saline substances proceed not from some internal thing, analogous to a seminal principle, causing in them a kind of maturation of some parts; which being once ripened, and perhaps assisted by the moisture of the air, disclose themselves in the saline concretions; as in the feculent or tartarous part of wines, there will, in tract of time, be generated or produced numerous corpuscles of a saline nature, that give the acid taste we find in tartar, especially in that of rhenish wine.

It may also be suspected, that the salts found in marcasites, nitrous and aluminous earths, &c. are made by the saline particles of the like nature, that, among multitudes of other kinds, swim in the air, and are attracted by similar particles yet remaining in the terrestrial bodies, which are, as it were, the wombs of such minerals; as a spirit of nitre will with fixed nitre, and some other alkalies, compose salt-petre: or else, that such aerial salts, assisted by the moisture of the air, soften, open, and almost corrode, or dissolve the more terrestrial substances of these wombs, and thereby sollicit and extricate the latent saline particles; and by their union with them, compose those resulting bodies that resemble vitriol, alum, &c.

But tho these considerations should be thought sufficient to rescue the production of salts from the effect of any hidden properties of the air, we have others which abundantly evince the existence of such properties: as, the air's access rendering antimonial medicines not only emetic, but also disposed to produce heart-burnings, faintings, &c. none of which, when kept from the air, they do at all tend to promote. Its affording strange prognosticks of plagues; as that of the person mentioned by Mr. Boyle, who for three successive plague-seasons had an odd tumour formed in his groin, about three months ere the plague began; by which he constantly foretold its approach: with infinite others to be met withal in naturalists, chemists, &c. as *Zwelfer*, *Boyle*, *Cardan*, *Scaliger*, *Diemerbroeck*, &c.

To account for the origin of such properties of the air, Mr. Boyle observes, that as we cannot pronounce so much as negatively whether the libration of the moon, and the motion of the sun, and perhaps of some of the other planets, about their own centres, and consequently their turning several parts of their bodies,

gold: that menstruum is found to act on this metal, partly by its gravity, and partly by the presence of the air; for, upon removing the air, it ceases any longer to dissolve the gold.

*Illustrated by
Papin's digestor.*

The vast effect of air, in determining bodies to one another, I have made trial of with great hazard of my life: for, putting a little spirit of wine, along with some of the more tenacious bodies, as gum sandarach, &c. in Papin's digestor, to dissolve; and applying a fire underneath; the air not being able to escape, expanded it self with immense force, and thus violently thrust the several matters against each other: so that the whole was, in a very short time, perfectly dissolved. But such was the expansive force of the imprisoned air, that a metalline cylinder, two inches thick, was thereby burst in my hand.

*Agitates the
parts of bodies.*

4°, Air being thus elastic, and insinuating it self into the pores of bodies, with so powerful a property of expanding, and this so easy to be excited; it must of necessity put the particles of all bodies it is mixed withal, into perpetual oscillations; unless these three conditions concur: 1°, That the gravity, or weight, wherewith it is pressed, remain the same. 2°, That the elastic force remains the same. 3°, That the contained fire continue the same, without augmentation or diminution. But, as such weight, elasticity, and rarefaction, are continually varying; it follows, that there must be an almost incessant vibration, or dilatation and contraction in all bodies.

*Exemplified in
ice, glass, marble, &c.*

Monsieur Mariotte observes, that if there be bubbles of air contained in a piece of ice; that air seeking it self a passage, will break the ice: and thus it is, that glasses, and other vessels, are frequently burst in the

bodies to us, may not have an operation upon our atmosphere; so, for ought we know, there may be in those vast internal parts of the earth, whose thin crust has been here and there dug into, considerable masses of matter that have periodical revolutions, accensions, estuations, fermentations, or in short, some other notable commotions; the effluvia whereof may produce effects yet unobserved on the atmosphere, and on some particular bodies exposed to it: tho these periods may, perhaps, be altogether irregular, or have some kind of regularity different from what one would expect: thus the sea has those grand intumescencies we call spring-tides, not every day, nor at any constant day of the month or week, but about the full and new moon; and these spring-tides are most notably heightened, not every month, but twice a year; at or about the vernal and autumnal equinoxes: which observations are not near so antient, and so well known, as the daily ebbing and flowing of the sea. The Etetians of the antients we do not now insist on, nor the observations of the elder inha-

bitants of the *Caribbee-Islands*; who, when the *Europeans* first resorted thither, had hurricanes but once in seven years; afterwards they were molested with them once in three years; of late they have been troubled with them almost every year: And a physician who had lived there since, assured us, he had scarce observed them to succeed one another in less compass than of two months. In which instances, and in several others, it may be noted, that in the changes which happen to great quantities of matter, nature seems to affect something of the periodical, but not in a way that appears to us regular. We may add what *Varenus* relates of those hot springs in *Germany* he calls *Therma piperina*, that they annually begin to flow at certain seasons; the former about the third of *May*, and the latter near the middle of *September*; from which time they rest till the following spring: To say nothing of numerous other periodical springs which flow, some of them so many hours, and some so many days, and then rest as many, alternately. See Boyle, as above cited.

winter

winter time, when the liquors they contain are frozen. Air, indeed, may remain in certain places, without activity; till, by some accidental union with other particles, it acquires an activity: and hence it is, that entire columns of marble, sometimes cleave in the winter season, from some little bubble of included air's acquiring an increased elasticity.

All solutive power, therefore, depends on air: for, as is already observed, *aqua fortis* cannot dissolve iron, or copper, in the receiver of an air-pump; but, when the air is let in, the solution is soon performed. And hence it is, that on the tops of high mountains, as the pike of *Tenariffe*, the most savory bodies, as salts, ginger, pepper, spirit of wine, *Taster.* &c. scarce affect the tongue and palate with any sensible taste at all; their particles not being pressed on the tongue, so as to enter its pores; but instead thereof, dissipated and blown away by its heat: the only thing that there retains its taste, is *Canary-wine*, which may be partly owing to its penetrative spirit, but probably, more to its oiliness, which makes it adhere more strongly, and not so easy to be dissipated by the heat of the tongue. Hence also it is, that salts do not dissolve so well in dry places; but best in cold places under ground, where the air being heavier, *The running of salts.* presses the parts more towards each other.

As the air is elastic, and as it expands or contracts differently, according to the different degrees of heat, and cold; and as these are variable, and rarely continue two minutes the same; it follows, that the air must be in continual motion: and thus it becomes the great cause why motion never ceases in the universe. This air, we find, produces a vibratory motion in several bodies, observed particularly in plants; the air-vessels whereof do the office of lungs: for, the air contained in them, sometimes contracting, and sometimes expanding, according as the heat is increased, or diminished, presses the vessels, and eases them again by turns; and thus promotes a circulation of their juices, which could scarce be otherwise effected. Hence, we find, that no vegetation or germination, will proceed in vacuo; for, as to what is commonly said of beans, *viz.* that they germinate there, it is a manifest mistake: indeed, they swell a little, by the expansion of the air contained within them; but they never bud. Perhaps no space can be assigned within the confines of our earth, but has air in it: to try whether there were any in a very intense fire, I placed a tube in a furnace, till it was ready to fuse; then, hermetically sealing it, as supposing it absolutely void of fire, I immersed it, thus sealed, in mercury, and in this condition broke off the seal: upon this the mercury rose, but not so high as in the barometer; which shews that there was still air in the tube to prevent its ascent. Air, therefore, is found in a fire where glass will melt. *Found in all places about our earth.*

And not only all solutions, but all putrefactions and fermentations, do likewise depend on the air, considered as it is elastic, and in continual motion; these two operations, which we shall hereafter shew are the grand means of changing, and converting vegetable and animal bodies, depend wholly on the action of the air, whose continual oscillations are inducing *Air the great instrument of putrefaction and fermentation.*

inducing perpetual changes both in solid and fluid bodies, pervious there-
to *. That the effect is not immediately owing to the action of fire †, is
evident hence, that there is the same degree of heat in vacuo, as in the
open air; and yet no putrefaction ensues in vacuo, either of animal or
vegetable bodies.

If you knead flour with water, void of all air, and lay it in vacuo;
it will never ferment †: nor will flesh putrefy without air; tho it
may resolve into a kind of sanies or filth ||. The like holds of liquids;
none of which will ferment, but such as have air in them, and at the
same time are in some measure viscid, to retain it. So, if you shut
up apples, flowers, &c. in an exhausted receiver, and keep them there
for six months, they shall be found still fresh and unaltered **.

* ' Are not the moist particles, which float
' in the air, the cause of all corruption in
' bodies; since, according to *Acosia*, every
' thing in *Pernu* (and the same is observed in
' *Egypt*) where it seldom rains, continues long
' uncorrupted? or is this resistance of putre-
' faction rather owing to the nitrous salt where-
' with the air of those countries abounds? '
Boyle's Hist. of Air.

Mr. Boyle gives us some singular instances
of the effect of the air, hardly deducible from
any of the known properties of this fluid.
Dr. Stubbs assured him, ' That the silks brought
' from *Jamaica*, will, if there exposed to the
' air, rot even whilst they preserve their co-
' lour; but if kept therefrom, hold both their
' strength and die.' *Ibid.*

The same author was informed by a learned
gentleman, ' That the air at *Brasil* had a
' great influence upon the colours of clothes,
' and even upon black; so that the sable taffety
' there worn by the higher rank, will, in a
' few days, become of an iron colour; tho,
' when kept close in shops, it preserves its
' proper hue. He also informed him, that at
' a place fifty leagues beyond *Parigua*, white
' people soon grew tawney; and as soon re-
' cover their native colour by removing out of
' that quarter.' *Ibid.*

*† Sir *Isaac Newton* looks for something
finer than common air to produce many of
the effects ascribed thereto: finding that heat
is conveyed and propagated even in vacuo,
he supposes a fine æthereal medium, or spi-
rit, subtiler enough to penetrate freely thro'
the most solid of all bodies. On which me-
dium, fire and light have their first imme-
diate effect, which is hence communicated,
by the vibrations of this medium, to the air,
and thence to other bodies. *Opticks.*

† ' The air, Sir *Isaac Newton* observes, a-
' bounds with acid vapours, fit to promote
' fermentations; as appears by the rusting of
' iron and copper in it, the kindling of fire
' by blowing, and the beating of the heart by
' means of respiration.

' The above-mentioned motions, he adds,
' are so great and violent as to shew that in
' fermentations the particles of bodies almost
' at rest, are put into new motions by a very
' potent principle, which acts upon them only
' when they approach one another, and causes
' them to meet and clash with great violence,
' and grow hot with the motion, and dash
' one another into pieces, and vanish into
' air, vapour, and flame.' *Opticks.*

|| The generation of animal substance being
the effect of putrefaction, as will hereafter be
made appear; it follows, that the presence of
the air is necessary for any piece of matter to
commence animal. Thus the philosopher so
often quoted, observes, that by keeping pu-
trified bodies in glasses hermetically sealed, and
thereby secured from the contact of the external
air, he had never been able to produce any
insect, or other living creature; tho he had
sometimes kept animal substances, and even
blood so included, for many months, and one
or two of them for a longer time; and tho
these substances had a manifest change made
in their consistence whilst they remained sealed
up. *Ubi supra.*

** Opening an exhausted receiver, wherein
a large quantity of verjuice with green, sour
grapes, had lain included for three years, there
appeared no mouldiness any where; only the
surface of the uppermost skins were a little
discoloured with something, which by its taste,
and appearance thro' a microscope, I suspected
to be a kind of tartar. *Id. ibid.*

The effect of the air, therefore, appears very great; since it can change the two kingdoms, and convert subjects of the one, into those of the other: what else is it that renders metals so very durable, and incorruptible, but their simplicity, and their not being pervious to the air? Thus, in places where no air is, there, no alterations happen; accordingly, it has been often observed, that names wrote in the sand, on the tops of the highest mountains, have remained there forty years together, without having been the least altered, or effaced.

Air, considered as a Chaos, a great Dissolvent.

NOW, the air, considered as a chaos, wherein all kinds of bodies float, may produce an infinite number of effects, hitherto not attended to.

There are two manners of dissolving: the first depends on the common properties of body; and therefore is mechanical. Thus, wood becomes divided and attenuated by means of the hardness, figure, cohesion, and motion of a sharp body, applied thereto. The second by some proper dissolvent or menstruum: thus gold is only soluble by mercury, fire, and *aqua regia*.

Now, we have already shewn that air is a solvent in the first capacity; as, by its weight, and elasticity it presses bodies against each other, and produces an attrition: and as it contains fire; which has likewise been shewn to be a dissolvent.

But air is likewise a chaos, and must therefore contain all kinds of *Air an universal menstruum.* menstrooms; and consequently have wherewithal to dissolve all kind of bodies; so that the air must likewise dissolve in the second capacity †.

† Mr. Boyle assures us, ' That he has several times made a substance, consisting of a metalline body of a texture so close as to lay for many hours undissolved in a corrosive menstruum; yet this substance, that was fixed enough to endure melting by the fire without losing its colour, would, when exposed to the air, be dissolved in a very short time, and have its superficial parts turned almost black.' *Ubi supra.*

Air, 'tis observed, may have a notable operation on vitriol, even after a strong fire could work no farther thereon. The experienced *Zwelfer* informs us, that the colcothar of this mineral, made by a strong distillation, is not corrosive; and that no salt can be obtained from it soon after distillation, by the affusion of water: but, says he, if it be for some time exposed to the air, it will yield a salt, which is sometimes white, and

sometimes a beautiful purple colour; and sometimes also a nitrous kind.

Mr. Boyle has even found the fumes of a sharp liquor to work more suddenly and manifestly on a certain metal, when sustained in the air, than did the menstruum it self, that emitted those fumes on those parts of the metal it covered. And a chemist, who had been in Hungary and other parts, purposely to visit mines, assured me, that as to the ladders and other wooden-works, employed in one or more of the deep Hungarian mines, those that were in the upper part of the grooves, near the external air, would, by the fretting exhalations, be rendered unserviceable in a few months; whilst such ladders, pieces of timber, &c. as were employed in the lower parts of the mine, would hold good two or three times as long. *Id. ibid.*

Metals turned
rusty thereby.

Except gold.

Air volatilizes
fixed bodies.

Even sea-salts.

Air fixes vola-
tile bodies.

This, accordingly, is matter of general observation; every body knows that iron and copper grow rusty in air. In the island of *Barbadoes* the air is so moist, that their instruments, unless well defended with oil, are soon dissolved. *Acosta* affirms, that the air in *Peru* dissolves lead, and withal increases its weight: and we our selves have seen pillars of iron so reduced by air, that one might crumble them to dust with the finger*: and stones † frequently undergo the same fate. Indeed gold may seem inaccessible to air; it being found never to contract rust, tho exposed ever so long to the open air. The reason is, that the only salt in nature, which dissolves gold, is the common sea-salt; which is not easily made volatile. So that air may be conceived as an universal || menstruum, now applying it self to this body, and then to that; and thus inducing dissolution, corruption, and putrefaction, in all things.

Air, in effect, not only dissolves but volatilizes abundance of bodies, which before were fixed: thus, if you calcine sea-salt by a vehement fire, and then fuse it; and when fused, expose it to the air in an open vessel, you will find it liquify: when liquified, let it dry again; and when dry, fuse it: and thus, by repeating the experiment, you will have all the salt vanish into air; leaving nothing behind but a little earth, and insipid water.

For the same reason, air fixes divers bodies which before were volatile: thus, nitre, or *aqua fortis*, evaporate by fire, but if there be any

* Copper that has been long exposed to the air, contracts a rust by the saline particles of that fluid, gradually fastning themselves in such numbers to the surface of the metal as to corrode it, and produce a substance of the colour of verdigrease; which is a factitious body, made of the same metal, corroded by the sharp corpuscles of vinegar, or of the husks of grapes. *Boyle Hid. Qual.*

Tho *Morocco* be an inland town, seated in a very hot climate, where the soil is usually dry; yet I am informed, that the nocturnal air proves exceeding damp and piercing, so as presently to produce rust upon such iron instruments as lie naked therein. *Id. Hist. of Air.*

In the most Southern parts of the *English* colonies, the great guns are so subject to rust, that after lying a few years in the open air, large cakes of *crocus martis* may, with a hammer, be easily beat off them; whilst others that lay sunk in the salt-water, during the same time, are by no means so much affected. Hence, as dew is only steams of the terrestrial globe, the phenomena that manifest its power to work on

solid bodies, may help to shew how much the air abounds with saline and subtile parts. *Id. ibid.*

† An experienced mason told me, that *Salisbury* cathedral is built of *Purbeck* stone, which gradually becomes softer, and moulders away in the air; that the same is observed from *Blackington* stone, tho kept from the wet: but what comes from *Painswick*, within four miles of *Glocester*, tho soft and pliable at the first, will, by lying in the air, acquire an hard, yellowish, glassy crust, like marble; which grows the more durable for being often washed. *Boyle, Hid. Qual.*

|| In bodies on which the aerial menstruum can operate, its immense quantity is of some advantage: for whereas even the strongest menstrea, if they bear no great proportion, in bulk, to the bodies they are to work on, are easily glutted, and being unable to take up any more, leave the rest of the body undissolved; this bears so vast a proportion to the bodies exposed to it, that when one portion of it has impregnated it self as much as 'tis able, there may still come fresh to operate farther on the remaining part of the body. *Id. ibid.*

putrefied urine near the place, the volatile spirit will be fixed, and fall down in form of *aqua secunda* †.

Add, that air brings a great many quiescent bodies into action, *i. e.* ^{Brings the latent powers of bodies into action.} Brings the latent powers of bodies into action; thus, if an acid vapour be diffused thro' the air; all things whereof that is a menstruum, will be dissolved thereby. Thus gold is dissolved by the vapour of spirit of sea-salt, and silver by that of nitre; and each contracts a rust: so that it was no groundless observation of the chemists, that there are active principles in the air.

From the whole we gather, that the objects of chemistry, in the same operation, applied in the same manner, and to the same fire, will not have the same effects, at different times, or in different places; by reason of the diversity of matters in the air.

Air, considered, both as invested with the forementioned properties, ^{Diversities in the air produce others in chemical operations.} *viz.* gravity, elasticity, &c. and as a chaos, may have infinitely various effects, which none but a chemist would know how to account for: some operations require an open air, without which they can never take; and in others, on the contrary, the air is to be totally excluded. If you take camphire, put it in a glass vessel, and set fire underneath it; the whole will run into salts, without any diminution of weight; whereas, if during the process, you take off the cover, and apply a candle to it, it will take fire, and the whole fly away in fume. So, to make sulphur inflammable, it requires the air; for in a close cucurbit it may be sublimed a thousand times without kindling: put sulphur under a glass bell, and apply fire; and it will rise into spirit of sulphur *per campanam*; and provided the vessels were close, will be incapable of catching fire, as much as gun-powder in the same circumstances: but if there be but the least chink, it immediately kindles. So an ounce of charcoal, inclosed in a crucible well covered and luted, to prevent any air's insinuating; may be kept in the intensest heat of a melting furnace fourteen days without any loss; and yet the thousandth part of the fire, in open air, readily turns it into ashes. *Helmont* relates, that if you take charcoal and put it in a close vessel, out of which the air is excluded, and here urge it for fourteen days in a glass furnace; the coal will still remain black: but the minute you let in air, it falls into white ashes. The same holds of the parts of all animals and vegetables, which can only be calcined in open air: in close vessels, they will never be other than black coals.

† Mr. Boyle mentions a certain soft but consistent chemical body, which in the free air continually emitted a thick smoke; but which, in an exhausted receiver, was not found to emit any: nay, by lying a-while in vacuo, it grew so far fixed, that it afterwards remained a good while in air, ere it would smoke again. And what was farther yet, when a vial, containing

some of it, was put unstopped in the receiver of the air-pump, close luted on; tho no exhaustion were made, yet the white fumes immediately ceased to ascend; as if the smoke participated of the nature of flame, and presently glutted the air, or otherwise made it unfit, without any diminishing of its gravity, to raise the body. *Hid. Qual. of Air.*

*Diversities in
the exhalations
produce others
in the opera-
tions.*

The changes, therefore, produced by chemistry are various, according as they are made in the open or inclosed air; rarefied, or dense; humid, or dry; light, or heavy, &c.

The same are likewise various, as the exhalations are so. We shall shew elsewhere that salts attract, and that air repels, water. *Helmous* mentions it as a mighty arcanum in chemistry, to render fixed salt of tartar volatile; but the thing is effected by air alone: for if you expose some of this salt to the air, in a place replete with acid vapours, the salt will draw the acid spirit to it self; and when saturated therewith, become volatile. But then it is no longer a mere alkaline salt, but a compound one. Hence a due regard to the state and disposition of the atmosphere, of the place, *e. g.* the air of the laboratory, is indispensibly required in any operation; without which, there is no answering for the event's being the same at one time as another. If *e. g.* there were 100 men in a place, the air, there, would be full of the matter of insensible perspiration; and a good blood-hound would readily distinguish that emitted by his master from all the rest, by the mere smell: Hence it follows, that the air must be very different where crowds of people are, as in cities, great assemblies, &c. from what it is in rural and solitary places. Thus much for air.



Of WATER.

WATER is a thing of a very extraordinary and wonderful nature, hitherto little known or understood. When considered in it Water not fluid of its own nature. self, it appears to be of the nature of a pure crystal: for a small degree of cold renders it, as it were, stony; and a great one turns it perfectly hard; so as even armour might be framed thereof. But fire puts it in motion; and by means hereof it becomes a fluid.

Water, if it could be had alone and pure, would be as simple as fire; None of our water pure. but there is no art or expedient yet found out for making it such: for rain-water, which seems to be the purest of all the waters we know of, is replete with exhalations of all kinds, which it imbibes from the air; so that tho' filtered and distilled a thousand times, there still remain faeces behind; and if it be let stand a little while, it corrupts and sinks. The rain-water gathered from the roofs of houses is a Rain-water a strange compound. lixivium of tiles, slate, or the like, impregnated with the dungs and faeces of animals, birds, &c. deposited thereon, and the exhalations of numerous other things. All the rain-water gathered in cities must at last be saturated with the smoke of a thousand chimneys, and the various effluvia of numbers of persons, &c. Add, that there is fire contained in all water; as is evident from its fluidity, which is owing to fire alone. No water without fire.

There is always something heterogeneous, therefore, remaining in water, as well as air; and as what is in the air necessarily mixes itself with water, it appears impossible to have such a thing as pure water: if you percolate it thro' sand, or squeeze it thro' pumice, or pass it thro' No operations make water pure. any other body of like kind, you will always have salt remaining. Nor can distillation render it pure; since it leaves the air therein, which abounds in corpuscles of all sorts. Accordingly we find that water, tho' distilled again and again, never fails to leave faeces behind; which Mr. Boyle assures us has been proved, even to the hundredth distillation.

Some years ago, I placed a large chemical vessel on the turret of our academy, in a clear night, when not a breath of wind seemed stirring; in order to gather the water, as it fell, in form of dew, or hoar-frost: hoping that by the great height of the place, and the precautions I had taken to prevent the admixture of any foreign matter, I should have water in all its purity. But tho' the water thus procured, was the purest I had seen; yet, by a gentle distillation continued for the space of a month, with a heat no greater than that of the human body, it left faeces full of various sorts of heterogeneous particles.

Hence I am convinced no body ever saw a drop of pure water. The utmost of its purity known, only amounts to its being clear of this or that.

that sort of matter. It can never, for instance, be quite deprived of salt; since air will always accompany it, and air has always salt.

Water an universal Instrument.

Water concern'd
in all opera-
tions.

Contained in all
bodies.

In all places.

Hartsborn as
hard as metal,
stones, &c.

Plentifully
found in dead
dry bones.

WATER is an universal instrument, concerned in almost all operations: for there is no air without water, as we have already shewn; nay, and what is more extraordinary, there is no fire without water. A single grain of the most fiery salt, which in a moment's time will penetrate thro' a man's hand, readily imbibes half its weight of water, and melts even in the driest air imaginable. Thus salt of tartar, placed in the driest air, and near the hottest fire, will attract or imbibe water; and by that means increases considerably its weight in a small time. So in the driest summer's-day, bring up a vessel, e. g. of pewter, with ice in it, from some cold subterraneous place, into the hottest room; and it shall no sooner be entred, than its whole surface will be covered with little drops of water, gathered from the contiguous air, and condensed by the coldness of the ice. Thus the windows of all hot places are continually found wet on the outsides; so that water is diffused every where. Which is further confirmed by the following experiment:

I took a quantity of rightly prepared oil of vitriol, and exposed it a long time to a violent fire to separate all the water, as much as possible, from the same; afterwards, by only standing a little while in the air, it contracted fresh water apace: so that it soon afforded me a considerable quantity more. I have harts-horn which has been kept for forty years, and is as hard and dry as any metal; so that if struck against a flint it will yield sparks of fire. And yet this very harts-horn, being put in a glass vessel and distilled, afforded me $\frac{1}{10}$ th of its quantity of water. We have known bones dead and dried twenty five years, and thus become almost as hard as iron; which yet, by distillation, afforded half their weight of water: and the hardest stones, ground and distilled, do always discover a portion thereof.

Opinions of Philosophers concerning Water.

Water held the
feminal mat-
ter of all things.

THALES, the Milesian, held, that all things were made of water; which opinion he had probably borrowed from the writings of Moses*, where he speaks of the Spirit of God's moving on the face of the waters.

After

* With regard to this, Mr. Boyle observes, | ' the Spirit is said to have brooded, as the
' That he sees no necessity to conceive, that | ' universal matter; was our elementary
' the water mentioned by Moses, on which | ' water; since, tho we should suppose it to
| ' have

After him, *Basil Valentine, Paracelsus, Van Helmont, Centivoglio*, and others, have maintained, on his principles, that water is the elemental matter, or stamen of all things; and that it suffices for the production of all things: which *Helmont* endeavours to prove from the following experiment.

He burnt a quantity of earth in a potter's vessel, till such time as all the oil it contained was quite consumed; then mixing it up with water, he drew out all the salt. The earth thus prepared, he put in an earthen pot, such as is used by gardeners; and took care that nothing but rain-water could enter into the same. And yet a willow being planted in this earth, grew up to a considerable height; whence he concluded, that water was the only nutriment of the vegetable kind, as vegetables are of the animal *.

‘ have been an agitated congeries, consisting
‘ of a great variety of seminal principles, and
‘ of other corpuscles fit to be subdued and
‘ fashioned by them, it might yet be a body
‘ fluid, like water, in case the corpuscles it
‘ was made up of, were, by their Creator,
‘ made small enough, and put into such an
‘ actual motion as might make them all roll,
‘ and glide over one another. And as we
‘ now say, the sea consists of water, notwithstanding the saline, terrestrial, and other
‘ bodies mixed with it; such a liquor as the
‘ former might well be called water; because
‘ that was the nearest of the known bodies
‘ whereto it was like. But that bodies
‘ may be fluid enough to appear a liquor, and
‘ yet contain corpuscles of a very different nature,
‘ appears from exposing a quantity of
‘ vitriol in a strong vessel to a competent
‘ fire; for tho it contains aqueous, earthy,
‘ saline, sulphureous and metalline parts, yet
‘ the whole mass will at first be fluid, and
‘ boil like water.’ *Scept. Chem.*

Dr. Lister's sentiment is not very remote from this: he imagines sea-water to have been the only element created at the beginning, before any animal or vegetable; or even before the sun himself. Fresh water he supposes to have arose accidentally, after the creation of these; and to owe its origin to the vapours of plants, the breath of animals, and the exhalations raised from the sun. *De Font. Med. Ang.*

Dr. Halley is of another opinion: he takes it for granted, that the saltiness of the sea arises from the saline matters dissolved and imbibed by the rivers in their progress, and discharged with their waters into the ocean; and consequently, that the degree of saltiness

is continually and gradually increasing. On this hypothesis he even proposes a method for determining the age of the world: for two experiments of the degree of saltiness, made at a large interval of time, will, by the rule of proportion, give the time wherein it has been acquiring its present degree. *Philos. Transact. N^o 344.*

* *Tho Helmont* produces no instance of any mineral body, and scarce of any animal, generated of water; yet a *French* chemist, *M. de Rochas*, affords us an experiment, which if it succeeded as he delivers it, is very remarkable. ‘ Having, *says he*, found surprizing things from the natural operation of water, I was willing to know what might be done with it by art: I therefore took pure water, and by a heat artificial, continual, and proportionate, I prepared and disposed it by the coagulation, congelation, and fixation, till it was turned into earth; which produced animals, vegetables, and minerals. The animals moved of themselves, eat, &c. and by the anatomy I made of them, I found them composed of much sulphur, little mercury, and less salt. The minerals began to grow and increase, by converting into their own nature one part of the earth thereto disposed; they were solid and heavy.’

For the generation of living creatures, both vegetable and sensitive, it need not seem incredible; since we find that our common water, which is often impregnated with variety of seminal principles, long kept in a quiet place, will putrefy; and then too, perhaps, produce moss and little worms, or other insects, according to the nature of the seeds that were lurking in it. *Boyle's Scept. Chemist.*

The

Disproved by
Dr. Woodward.

Pure water
affords no nu-
triment.

All bodies held
convertible into
water.
Particularly all
spirits.

Salts.

Acid salts.

The same thing Mr. Boyle likewise argued from a similar experiment. But Dr. Woodward shews that they were both mistaken: he proves, that water contains in it divers extraneous corpuscles, and that some of these are the proper matter of nutrition; water being found to afford so much the less nourishment, the more it is purified: thus mint planted in water purified by distillation, will not grow so fast as if put in water not distilled; and if the water be distilled three or four times over, the plant will scarce grow at all, or receive any nourishment from it. So that water, as such, is not the proper nutriment of vegetables, but only the vehicle thereof, which contains the nutritious particles, and carries them along with it, thro' all parts of the plant. So that a water-plant, *e. g.* a nasturtium, being put in a glass vessel, full of water, will be found to contain the more salt and oil, the muddier the water is; in effect, water nourishes the less, the more it is purged of its saponaceous salts: in its pure state, it may suffice to extend, or swell the parts; but affords no new vegetable matter.

Helmont likewise imagined, that all bodies might be converted into pure elementary water*. From mixed bodies, 'tis certain, we can draw water, oil, spirit, salt and earth. Now spirits cannot be better represented than by alcohol of wine; which, *Helmont* affirms, may be so united with water, as to become water it self†.

As to salts; salt of tartar well calcined, being laid to liquify in air, will deposit an earth; and if it be then committed to distillation, will yield a considerable quantity of insipid water; insomuch, that if it be urged with a vehement fire, the salt will almost all vanish, and nothing saline remain either in the water or the earth. Whence *Helmont* concluded, that all salts might be converted into water. As to the conversion of acid salts into water; sea-salt, recover'd from the acid spirit of sea-salt and oil of tartar, melts into water, as much as into oil of tartar. Lastly,

* *Helmont* affirms, that his alkalest adequately resolves plants, animals, and minerals, into one liquor, or more, according to their several internal differences of parts; and that the alkalest, being abstracted from these liquors, in the same weight, and with the same virtues as when it dissolved them, the liquors may, by frequent cohobations from chalk, or some other proper matter, be totally deprived of their seminal endowments, and return at last to their first matter, insipid water.

† Tho spirit of wine exquisitely rectified, seems of all liquors the most free from water, yet even this is by *Helmont* affirmed to be materially water, under a sulphureous disguise; for, according to him, in making *Paracelsus's balsamus samech* (which is nothing but sal

tartari dulcified, by distilling spirit of wine from it, till the salt be sufficiently saturated with its sulphur, and till it suffers the liquor to be drawn off as strong as it was poured on) when the salt of tartar, from which it is distilled, hath retained or deprived it of the sulphureous parts of the spirit of wine, the rest, which is incomparably the greatest part of the liquor, will turn to phlegm.

Corrosive spirits, says Mr. Boyle, abound in water; which may be observed, by entangling and so fixing their saline parts, as to make them corrode some proper body; or else, by mortifying them with some contrary salt, which will turn them into phlegm.

Boyle's Scept. Chemist.

Oils run in great measure into water; and, 'tis probable, might be converted wholly into the same †.

If this be true, it should seem that earth alone is unchangeable; and that water is the matter whereof all things are composed: whence some philosophers deduce the reason of the *Latin* name *Aquâ*. But the truth is, we have not experiments sufficient to warrant such conclusion; pure, elementary water being wanting to make experiments upon.

Fluidity of Water.

WATER is fluid; but this fluidity is not natural thereto, but extraneous and violent. For, naturally, it is of the crystalline kind; ^{Water naturally firm.} and accordingly, wherever a certain degree of fire is wanting, there we see the water become ice *. That this ice is the proper effect of the want of heat, and not of any additional spicula introduced into the water, as *Mariotte* and others contend, is evident enough, were it only hence, that on this supposition it could not penetrate the substance of all bodies, as we find it does, and even that of metals.

This water, in its state of solution, never remains at rest: Its parts ^{Always in motion.} are in perpetual motion; as was first discovered by the *French*, with the help of microscopes; and is further confirmed from this, that if a little ^{Argued from solutions,} saffron be suspended in the middle of a vessel full of water, the saffron colour will, in a little time, form, as it were, a kind of atmosphere around, and at length be diffused thro' the whole water. Now this could no way be effected without a motion of the watery particles

† 'Tis surprizing to observe, how great a share of water goes to make up several bodies, whose forms promise nothing near so much: Eels, by distillation, yielded me some oil, spirit, and volatile salt, besides the *caput mortuum*; yet all these were so disproportionate to the phlegm, that they seemed to have been nothing but that coagulated; which, likewise, strangely abounds in vipers, tho they are esteemed very hot in operation, and will, in a convenient air, survive, for some days, the loss of their heads and hearts. Human blood it self, as spirituous and elaborate a liquor as 'tis reputed, so abounds in phlegm, that distilling some of it, on purpose to try the experiment, out of about seven ounces and an half, we drew near six of phlegm, before any of these operative principles began to rise.

Boyle's Scept. Chemist.

* Thus Mr. Boyle: 'Ice is usually said to be water brought into a preternatural state by cold; but with regard to the nature of

things, and setting aside our arbitrary ideas, it might full as justly be said that water is ice preternaturally thawed by heat. If it be urged that ice, left to it self, will, upon the removal of the freezing agents, return to water; it may be answered, That not to mention the snow and ice which lie all the summer long on the *Alps* and other high mountains, even in the torrid zone, we have been assured that in some parts of *Siberia* the surface of the ground continues more months of the year frozen by the natural temperature of the climate, than thawed by the heat of the sun; and that a little below the surface of the ground, the water which chances to be lodged in the cavities of the soil, continues in a state of ice all the year round: so that when in the heat of summer the fields are covered with corn, if you dig a foot or two deep, you shall find ice and a frozen soil.' *Natural and preternatural state of bodies.*

Sf

among

among each other. Add, that if you cast a quantity of the driest salt, in the coldest weather, into water, it will soon be dissolved; which argues the continual motion of the particles of that element ||.

The microscope.

I have more than once filled a large, wide vessel with water, and narrowly watched it with a good microscope; but never could perceive it without some sort of undulatory motion.

Specific gravity of water perpetually varying.

Water scarce ever continues two moments exactly of the same weight, but is always varying more or less, by reason of the air and fire contained in it: thus, if you lay a piece of pure limpid ice in a nice balance, you will never find it continue in equilibrium. The expansion of water in boiling, shews what effect the different degree of fire has on the gravity of water.

This uncertainty makes it difficult to fix the specific gravity of water, in order to settle its degree of purity; but this we may say in the general, that the purest water we can procure, is that which weighs 880 times as much as air. However, neither have we any tolerable standard in air; for water being so much heavier than air, the more water is contained in air, the heavier of course must it be: as, in effect, the principal part of the weight of the atmosphere seems to arise from the water.

The purest natural water, Rain.

Of all waters, the purest is that which falls in rain, in a cold season, and a still sky; and this we must be contented to take for elementary water. The rain-water in summer, or when the atmosphere is in commotion, 'tis certain must contain infinite kinds of heterogeneous matter: Thus if you gather the water that falls after a thunder-clap, in a sultry summer's day, and let it stand and settle, you will find a real salt sticking at bottom. But in winter, especially when it freezes, the exhalations are but few; so that the rain falls without much adulteration: And hence, what is thus gathered, in the morning time, is found of good use for taking away spots in the face; and that gathered from snow, against inflammations of the eyes. Yet this rain-water, with all its purity, may be filtered and distilled a thousand times, and it will still leave some faces behind it; so that to procure the purest water possible, a man must look for it in a large, spacious plain, in the winter time, when the earth is covered with snow, and its pores locked up with frost.

Then spring-water.

The next, in point of purity, is *spring-water*: This, according to Dr. Halley, is collected from the air it self; which being saturated with water, and coming to be condensed by the evening's cold, is driven

|| These instances of the solution of salts in water may be accounted for on Sir Isaac Newton's principles, without supposing the particles of the fluid in continual motion. True, to effect a solution, there must first be motion; but that motion need not be supposed to have existed before the application of the salt to the water. It may have arose from the mutual attraction between the particles of the water, and the salt; which being stronger than that between the particles of the salt, may induce a separation thereof, and occasion them to recede from each other, and diffuse themselves throughout the water.

again

against the cold tops of mountains; where being further condensed and collected, it gleets down, or distills, much as in an alembic. This wa- *River-water.* ter, which before floated in the atmosphere in form of vapour, being thus brought together, at first forms little streams, several of which meeting together form rivulets, and these, at length, *rivers.*

If such water chances to flow over strata, or beds, wherein there is *Mineral-water.* salt, or sulphur, or vitriol, or iron, or copper, or the like; the water becomes medicinal: but the basis, it may still be observed, is rain-water*.

Spring-water becomes the better by running; for during all its course, it is depositing what heterogenous matters it contained. And hence the antient poets and painters represent the deities of springs and rivers, as combing or carding their waters. They also paint them as holding an inclined urn, or vessel, out of which the water continually flows. Hence *Virgil*:

*Pocula sunt fontes liquidi, aut exercita cursu
Flumina.*

For while the river drives on its waters in an uninterrupted stream; all its salts, with all the vegetable and animal matters drained into it, either from exhalations, or from the ground it washes, gradually, either sink to the bottom, or are driven to the shore.

However, as there is still found sea-weed, with snails, toads, and other animals, in rivers; it follows, that river-water is not so pure as that of springs †.

But what water descends from springs, on the tops of mountains, is generally pretty free from heterogeneous bodies; and as such, is much commended by the antients as conducing to long life: *Herodotus* relates, that some people drank a water which was so very light, that all woods immersed in it immediately sunk to the bottom; and *Hippocrates* him-

* Some springs are much more copiously impregnated than others; and therefore will bear a greater dilution by rain-water: Thus, tho I have found more than one of our *English* ferruginous springs, especially those near *London*, too much weakened by water that rained into them; yet upon carefully trying how much of that fluid some *German* spaw-water, which came very well conditioned to *London*, would bear, it appeared, that when this was diluted with no less than thrice its weight of rain-water, it still retained strength enough to produce a purplish colour, with fresh powder galls. *Boyle's Nat. Hist. of Mineral Waters.*

† That the *Thames*-water, when carried long voyages, and into hot climates,

will have a very offensive scent; the common putrefaction of stagnant water may persuade us: yet 'tis found, if that be kept long enough, tho in the same vessel, and a hotter climate; it will at length grow sweet and potable again. Several other waters have the same faculty of recovering after putrefaction, as well as that of the *Thames*, whereto 'tis usually supposed peculiar. And having had the curiosity to try how the rougher kind of water, that will not bear soap, might be remedied; an industrious person, whom I employed, assured me he had met with pump-waters, that barely by standing a few days, would gain this property. *Boyle's Usefulness of Exper. Philos.*

self, in his treatise *de Aere, Aqua & Locis*, observes, that the lightest water is the best †.

The purest water we can any way procure, is that distilled from snow, gathered in a clear, still, pinching night, in some very high place; taking none but just the outer or superficial part thereof: by a number of repeated distillations hereof, you will separate the greatest part of the earth, and other faces, and thus have a pure water.

Water always
yields earth,
and supposed
convertible into
it.

However, water can never be distilled so perfectly, as to have nothing heterogeneous therein: Mr. Boyle relates, that a friend of his distilled a quantity thereof an hundred times; who found at length, that he had got $\frac{1}{100}$ ths of the quantity of water, in earth. Hence he concludes that the whole water might, by further prosecuting the ope-

† Physicians generally suppose the light and pure water the most wholesome; so that an easy contrivance to know when water has these properties, would be of service. We have been told, that water brought out of *Africa* into *England* was found, by common scales, to be specifically lighter than ours, by four ounces in the pint. Thus many kinds of pump-water will not bear soap, and some will not dye scarlet or other particular colours.

Dr. Hook has contrived a water-poise, which may be of good service in examining the purity, &c. of water: It consists of a round glass ball, like a bolt-head, about three inches in diameter, with a narrow stem or neck $\frac{1}{4}$ th of an inch; which being poised with red-lead, so as to make it but little heavier than a pure, sweet water, and thus fitted to one end of a fine balance, with a counter-poise at the other; upon the least addition of even $\frac{1}{10000}$ th part of salt to a quantity of water, half an inch of the neck will emerge above the water, more than did before. *Philos. Trans.* N° 197.

It is generally granted, that those waters, *ceteris paribus*, are the best, as well for wholesomeness as other various economical uses, &c. that are freeest from saltiness; which is an adventitious, and in most cases a hurtful quality in waters. Mr. Boyle therefore contrived a very extraordinary method of examining the freshness and saltiness of waters by a precipitant, which could discover one part of salt in 1000, nay, 2 or 3000 parts of water. This he proved before King Charles II. but he was enjoined to keep it a secret. *Ibid.*

‘I have often found an unsuspected sea-salt in water, by pouring therein a so-

lution of fine silver, made in *aqua fortis*: for as common salt, or its spirit, will precipitate the metal in form of a white calx, in such a solution; I imagined, if the water in its passage thro’ the earth, gained even so few saline corpuscles, they would act, tho’ faintly, upon the dissolved particles of silver; and accordingly, upon their mixture, a kind of whiteness immediately ensued. This experiment has taught me to avoid such water, and to use in its stead rain-water, or that which had been freed from its salt by gentle distillation.’ *Boyle’s Useful, of Exper. Philos.*

Divers means have been attempted for making sea-water sweet: *M. Houton* had a secret for this purpose, which he at length discovered in the History of the Royal Academy. It consisted in first precipitating the water with oil of tartar, then distilling, and lastly, filtrating it thro’ a peculiar sort of earth, which he mixes with it, and suffers to settle to the bottom. After these three operations, the water remains perfectly wholesome.

Dr. Lister holds, that salt-water is rendered fresh by the breath of plants growing in it; and accordingly gives us an experiment where, in some common sea-weed, or *alga marina*, being set in a glass body of salt-water, distilled every day, without any fire, a quantity of pure potable water. *Philos. Trans.* N° 156.

The thawed ice of sea-water is often used in *Amsterdam* for brewing. And *Bartholinus*, in his book *de nivis usu*, confirms this relation in the following words: ‘Tis certainly says he, that if the ice of the sea-water be thawed, it loses its saltiness; as has been lately tried by a professor in our university.’

ration, be converted into earth *. But it should be considered, that the water can never be removed or poured into any vessel, without the mixture of some dust therewith: so, neither can the luting of the vessel be distilled without losing something every time. I should rather conclude, therefore, that the water thus often distilled, acquired still new earth from the dust continually floating in the air. This dust appears very sensibly in a dark place, where, after we have staid a-while without any motion, or the least wind to raise a dust, upon admitting a ray or two of the sun thro' a little aperture, we shall perceive the air swarm with legions of floating particles of dust: The like may be concluded from a black cloth; which, tho exposed in the stillest place, shall soon be covered over with thick dust.

I have taken some of the water, mentioned above, to have been gathered on the turret of the academy; and after distilling it by a gentle fire, for the space of four months, it has appeared perfectly pure; and yet, leaving it to rest in vessels exactly closed, it would conceive a slender kind of weedy-matter, somewhat like the stamina of plants, or the little tufts of a mucilage.

And yet a *Roman* chemist shutting up a quantity of pure water, in a vessel sealed hermetically, *Schottus*, who saw it in *Kircher's Museum*, after it had been so kept upwards of fifty years, affirms that it still remained clear and pure, and stood to the same height in the vessel as at first, and had not the least sediment at bottom †.

Chemical

* This instance of the convertibility of water into earth, is so considerable, that it may deserve to be delivered more at large: The author relates, 'That having put a considerable quantity of distilled rain-water into a clean glass body, and fixed it with a head and receiver, he suffered it to stand in a digestive furnace, till by the gentle heat thereof, the water was totally abstracted, and the vessel left dry; when being taken out of the sand, he found the bottom of the glass wholly covered with a whitish substance; which being scraped off with a knife, appeared to be a fine earth, without any manifest taste.— This encouraged him to distil the rain-water again, in the same glass body; in the bottom whereof, when the water was all drawn off, lay more of the like earth, which confirmed his conjecture, that the earthy powder might be a transmutation of some parts of the water into that substance. Herein he was farther encouraged by a physician, who assured him, that he had frequently found such white earth in rain-water, after distilling the same many times successively; adding, that he found no cause to suspect, that if he had continued to re-distil the same portion of water, it would have yielded him more earth. Lastly, a very ingenious person, who had tried various experiments on rain-water, put him beyond all doubts about this transmutation: for he solemnly affirmed, on experience, that rain-water, even after distillation in very clean glasses, near two hundred times, afforded him this white earth, and that more conspicuously in the latter distillations than in the former.' *Boyle of Forms and Qualities.*

† 'Tis disputed whether or no water be convertible into air. In the vapours daily raised, we find water rarefied to a great degree, so as to take place in the atmosphere, and help to compose a considerable part of what we call air; and even to contribute to many of the effects ascribed to the air: But such vapour-air has not the characters of true permanent air, being easily reducible into water again. So, in digestions and distillations, tho water may be rarified into vapours, yet it is not really changed into air, but only divided by heat, and diffused into very minute parts; which

*Differences in
water diversify
the effect of
chemical opera-
tions.*

Chemical operations succeed differently, according to the difference of water: We frequently observe a surprizing diversity in the effect of the same operation, conducted after the very same manner; which not being otherwise accountable for, has given many a handle to call the experiments in question. But it is my opinion, that the difference of the water, used by the different operators, may be one great cause of that variation: thus, if you use water gathered in a place where the air is very cloudy, the great number of foreign bodies thence imbibed into the water, may make a great alteration in the effect of the experiment. So pure water, void of salts, is best for producing the *arbor diana*; and if you attempt to make it with a water impregnated with salts, the experiment will not succeed: And hence it is, that many chemists held this tree a chemical non entity. The water of *Leyden*, being replete with a vitriolic alum, discharged into the same from the dyers vessels, we have already observed, is much better for dying of scarlet than the waters of *Haerlem*, *Delft*, *Amsterdam*, or any other place in the same country. Add, that the water gathered in pits, near stables, &c. becoming nitrous, excels all others for fertilizing the ground; tho the same circumstance renders them the less proper for numerous other operations.

Penetrability of Water.

*Water the most
subtle and pe-
netrative of all
bodies except
fire.*

WATER is the most penetrative of all bodies, next after fire; for which reason, it is very difficult to confine it: insomuch, that a vessel, thro' which water cannot pass, may retain any thing. Nor is it any objection, that syrups and oils will sometimes pass thro' vessels which water cannot pass; for this is not owing to the greater subtlety, or penetration of their particles, but to this, that such vessels are made of wood wherein rosin abounds, to which oils and syrups are men- struums; so that dissolving the resin, they make their way thro' the

which meeting together, presently return to such water as they constituted before.

Water rarified into vapour in an eolipyle, will, for a while, have an elastic power, like that of air, and be driven out in a stream much resembling air; but the elastic power of this stream is manifestly owing to nothing else but the heat that expands and agitates the aqueous particles thereof; and when that heat is gone, the elasticity and other aerial properties disappear likewise. Rapid winds thus made, seem to be no more than mere water broke into little parts, and put into motion; since by holding a solid, smooth, and close body against it, the vapours condensing thereon, will presently cover the body with water.

‘ Tho no heat intervenes, says Mr. Boyle, perhaps motion alone, if vehement, may suffice to break water into minute parts, and make them ascend upwards, if they cannot, otherwise, more easily continue their agitation: For, I remember, that betwixt *Lyons* and *Geneva*, where the *Rhone* is suddenly straitned by two rocks, exceedingly near each other, that rapid stream, dashing with great impetuosity against them, breaks part of its water into such minute corpuscles, and gives it such a motion, that a mist, as it were, may be observed at a considerable distance, arising from the place, and ascending high into the air.’ *Phys. Mechan. Exper.*

spaces left thereby. Whereas water, as does not act on resins, is retained in these vessels.

Water, however, does gradually make its way thro' all woods, and is only retainable in glass and metals: nay, it was found by experiment at Florence, that water shut up in a spherical vessel of gold, and then pressed with a great force, made its way thro' the pores even of gold: So that the most solid body in nature, is permeable to water. *Piercesse woods, metals, and gold itself.*

Water is even more fluid than air; for we account a body is more fluid than another when its parts will make their way thro' smaller pores: Now air, 'tis known, will not pass thro' leather, as is evident by covering an exhausted receiver therewith; but water goes thro' it with ease. Again, air may be retained in a bladder; whereas water oozes thro'*. In effect, 'tis found that water will pass thro' pores ten times smaller than air will. *Water more in a fluid than air.*

All that has been said of air, with regard to the composition of bodies, holds much more of water; as being both more penetrative and more ponderous. It enters the composition, therefore, of all bodies, both vegetables, animals and fossils; and has this circumstance peculiar to it, that it is easily separable from any of the bodies it unites withal; which cannot be said of any other body. Fire, indeed, will penetrate more than water; but then it is difficult to separate it again from the bodies it is once fixed in; as is evident in red-lead, &c.

This property of water, joined with its smoothness and lubricity, renders it fit to serve as a vehicle, for the commodious and easy conveyance of the nutritious matter of all bodies: for in being so very fluid, and passing and re-passing so readily, it never stops up the pores, but leaves room for the following water to bring on a new supply of nutritious matter. *A proper vehicle of nutriment.*

Water renders many bodies solid and hard.

IT has been observed, that water does not adhere to bodies with a lentor or visciditv; as is the case in alcohol, oil, or the like bodies: thus it rarely leaves any stræ on glass, nor is it to be drawn into stræ; but it easily unites with them, and is easily parted from them: Ordinarily it is even separable from them by a gentle degree of heat; except from such as imbibe it, as salt of tartar, oil of vitriol, &c. from which it is not separable without great difficulty. And yet the same water will cohere firmly with many matters, and bind them together,

* M. Homberg is of opinion, that water enters such narrow pores of animal substances, as will not admit the air, only because it moistens and dissolves the glutinous matter of the fine fibres of the membranes: and also renders them more pliable and distractile; which are things that the air, for

want of a wetting property, cannot do. As a proof of this doctrine, he filled a bladder with air, and compressed it with a stone, and found no air to come out: but placing the bladder, thus compressed in water, that air easily escaped. *Hist. de l'Acad. Ann. 1700. p. 45.*

so as to form them into the most solid bodies. Tho it will appear very wonderful, that water, which is, as it were, an universal dissolvent, should withal be a great coagulator.

*Water cements,
or binds to-
gether the parts
of many bodies,
as wood.*

Thus water mixed up with earth or ashes, gives them the utmost firmness and fixity: The ashes, for instance, of an animal, well incorporated with pure water, and made into a paste; and this baked by a vehement fire, grow into a cupel which shall bear the utmost effort of the refiner's furnace. 'Tis by water alone that our houses stand: for take the water out of wood, and it becomes ashes; or out of tyles, and they become mere dust.

Tyles.

Potters-ware.

Thus a little clay, dried in the sun, becomes a powder; which powder being mixed with water, sticks again together; so that you may fashion it at pleasure: and this, dried again by a gentle fire, or in the sun, and then baked in a potter's oven by an intense fire, becomes little other than a stone. Which is what mere water alone does; oil will not do it.

Porcelain.

So the *Chinese* or *Japan* earth whereof our porcelain vessels are made, which hold all liquors, and even melted lead it self, is diluted and wrought up with water. In effect, all the stability and firmness that is seen in the universe is owing to water alone: thus stone would be an incoherent sand, did not water bind it together.

Stone.

Bricks.

Thus, again, of a fat, gravelly earth, wrought up with water, and baked or burnt, we make bricks, tyles, and earthen vessels, of such exceeding hardness and closeness, that water cannot pass thro' them. And these bodies, tho to appearance perfectly dry and destitute of water; yet, if they be pulverized and put in a retort, and distilled, yield an incredible quantity of water: Whence it appears, that the particles of water may be so diffused, and dispersed thro' bodies, as to cohere with them, and give them hardness (for the particles of sand would never stick together without water) and yet may be fetched back again, and reduced to their former fluid state. And the same holds of metal; for the parings or filings of lead, tin, antimony, &c. by distillation, yield water very plentifully: And the hardest stones, sea-salt, nitre, vitriol, sulphur, &c. are found to consist chiefly of water, into which they resolve by force of fire, and lose the cohesion of their parts. Thus if you distil *sal gemma*, which is a very hard transparent body, like crystal, a good quantity of water will arise; and then the body, which before was transparent, becomes opaque, white, and friable.

Metals.

Salts.

Limestone.

The *lapis calcarius*, or lime-stone, being exposed to the fire, affords a prodigious quantity of pure water; and the more of this water is expressed, the more friable does it become, till at length it commences a dry calx or lime; wherein, in lieu of the water so expelled, the fire, in the course of calcination, enters; which is expelled again, in its turn, by pouring on cold water. Lastly, of the water and calx tempered together, arises a mass, scarce inferior, in point of solidity, to the primitive lime-stone. So that the *lapis calcarius* appears to be no more than limy-earth, bound into a hard substance by water.

Mortar.

From

From what has been said, it appears, that water is the universal gluten, which binds together the parts of all bodies: And hence that observation of *Cemivoglio*, Nature makes diamonds of a water well depurated and harden'd into a mass.

Water not elastic.

THAT water is not elastic, is evident hence, that it is incompressible, or incapable, by any means, of being reduced into less compass, tho' urged with the greatest weight: this we learn from that famous experiment made by order of the great duke of *Tuscany*; where a quantity of water being closely included in a hollow ball of pure gold, and thus laid in a press, with a prodigious force thereon; the ball not being able to assume a more copious figure, to give more room for the water; and the water being incapable of condensation; rather than yield, it transuded thro' the pores of the metal; so that the ball was found wet all over on the outside. Till, at length, making a cleft in the gold, it spun out with great vehemence: from which circumstance, some have concluded that it was elastic; but on weak grounds; the impetus wherewith the water darted out, being more probably owing to the elastic force of the gold, which communicated that impression to the water. Water incompressible and unelastic.

And hence we see the reason why blocks of marble sometimes burst in cold weather; and why water which has once filled a concave body, that afterwards, by any means, comes to be reduced into less compass, bursts the vessel, tho' ever so strong. This is very observable in a piece of brass canon; which being filled with water, and the mouth exactly stopped so as to prevent all egress of water: If a cold night happens, sufficient to contract and constipate bodies; the metallic matter undergoing the common fate, and the water refusing to give way, the canon is burst asunder with incredible violence. Tho' others account for the effect from this, that the included water, in freezing, endeavours to expand it self, or possess more room than before; which being denied, it bursts thro' its restraint. Bursts blocks of marble, brass, canons, &c.

Some bring an argument for the elasticity of water hence, that hot water takes up more room than cold: But no legitimate conclusion can be formed hence; for in the hot water there is a good quantity of fire contained, which interposing between the particles of the water, makes it extend to a greater space, without any expansion of parts from its own elasticity. This is evident hence, that if water be once heated, there is no reducing it to its former dimensions, but by letting it cool again; which plainly shews, that the expansion depends not on the elasticity of the parts, but on the presence of fire. Water then, tho' incapable of compression or condensation, may yet be rarified by heat, and contracted Water expands by heat, and why.

contracted by cold *. So that fire may act on some bodies that are not elastic.

If it be asked, how it happens that a body so light, fluid, and volatile, and which so easy a fire suffices to rarify, should be so stubborn and incompressible? we see no other cause to assign, but the homogeneity of its parts. If water be considered as consisting of spherical, or cubical particles, hollow within, and of a firm texture, here will be enough to account for the whole. Its firmness and similarity will make it resist sufficiently; and its vacuity render it light enough, &c.

Properties of the Particles of Water.

FROM what has been said, we may settle something as to the nature of the component particles of water: And,

The particles of water are extremely small.
Smooth.

1^o, The particles whereof water consists, are, as to our senses, infinitely small; as appears from their prodigious penetrative power.

2^o, They are exceedingly smooth and slippery, void of any sensibility; as appears from their being so easily separable from other bodies they adhere to.

Solid.

3^o, They are extremely solid; as appears from their cohering with other bodies into a solid form.

Transparent and invisible.

4^o, They are perfectly transparent, and, as such, invisible: This we gather, 1^o, From hence, that pure water inclosed in a clean vessel hermetically sealed, projects no shadow; so that the eye shall not be able

* It may be added, that a further degree of cold, that is, such a one as congeals water, or turns it into ice, does expand it. There are other ways to manifest this expansion of water by freezing: Mr. Boyle having poured a proper quantity of water into a strong cylindrical earthen vessel, he exposed it, uncovered, both to the open air in frosty nights, and the operation of snow and salt; and found that the ice produced in both cases, reached higher than the water before 'twas froze.

So if a concave cylinder, made of any compact matter, be tightly stopped at one end with wax, and filled with water at the other, and then that also be closed in the same manner; if, I say, this pipe be suspended in the air sufficiently cold, the contained water will be froze, and the stopples at both ends, or at least at one, will be thrown out; and a rod of ice appear thereat, in continuation with the tube.

A Stonecutter complained to Mr. Boyle, that sometimes, thro' the negligence of the servants, the rain being suffered to soak into marble, the violent frosts coming on, would burst the

stones. And another tradesman complained, that even implements made of bell-metal, being carelessly exposed to the wet, have been broken and spoiled by the water; which having entered at the little cavities of the metal, was there afterwards froze, and expanded into ice. And Cabeus tells us, that he saw a huge vessel, of exceeding hard metal, split asunder by congealed water.

Busbequius relates, ' That at Constantinople a monstrous obelisk, thrown from its pedestal in the city, had remained at its length for many ages; till in later times an architect appeared, who for a certain sum undertook to set it again upon its base; and having to this end prepared abundance of machines, he therewith raised it within an inch of its due height; then throwing water on the ropes that supported the pillar, they gradually contracted and set it upon its base. To render this the more credible, the like is mentioned by many eminent authors, as having been elsewhere practised; and the thing is allowed of by Galileo.

to discover whether the vessel have water in it or not. 2°. In that the crystals of salts, when the water is separated from them, lose their transparency.

3°. They are very rigid and inflexible; as appears from their not being compressible: *Des Cartes* supposed the particles of water of an eel-like form, to account for their lubricity; but, on this footing, they could not be incompressible.

It is observed, that when salt is infused in water, it does not fill the vessel in proportion to its own bulk; whence it follows, that there must be some little spaces between its particles, to admit those of the salt. And hence again we gather, that the watry particles are solid and inflexible; since, tho they have intermediate spaces, yet no force or weight can any way compress or crowd them nearer together.

From the whole it follows, that water, devoid of any heterogeneous admixture, consists of exceedingly minute, penetrative, fluid, slippery, solid, ponderous particles; and consequently, approaches near to the nature of mercury: And hence that observation of the antient chemists, *That mercury is the only body in nature that dissolves*; alluding to the menstruous virtue of water.

Water insipid and inodorous.

WATER is the most insipid of all bodies; for the taste we sometimes observe therein, does not arise from the mere water, but from some salt, vitriol, or other bodies mixed with it: And accordingly, all the waters that are savoury, as those of *Italy*, &c. and which are recommended by the physicians for medicinal uses, are always found to deposit a quantity of some of these fossils.

Nor does it appear, by any experiment, that water has the least smell; provided it be pure; so that water might remain imperceptible to us were it not for our sense of touching.

Water, therefore, appears to be perfectly indifferent as to the assuming of all forms: *Centivoglio* maintains, that if it happen to fall in a place where there is, e. g. pure cinnabar, or any other matter, the water will join with them all, and become what they are: which opinion falls in with that of *Thales* and *Paracelsus* above-mentioned*. And hence it is, that water is called a *second mercury*.

* All birds, beasts, and fishes, insects, trees and vegetables, with their several parts, grow out of water, and watry tinctures and salts; and by putrefaction, return again into watry substances. Water, standing a few days in the open air, yields a tincture; which (like that of malt) by standing longer,

‘ yields a sediment, and a spirit; but before putrefaction, is fit nourishment for animals and vegetables. And, among such various and strange transmutations, why may not nature change bodies into light, and light into bodies.’ *Newton’s Opticks*, p. 349, 350.

*The solutive Power of Water.**Water the only
dissolvent of
salts,*

FOR what relates to *water*, considered as a menstruum; it dissolves;
 1°, All salts, as sugar, borax, &c. which air only dissolves in virtue of the water it contains; which fire only liquifies, and earth leaves untouched: so that water alone is the proper menstruum of salts.

The particles of salts, we have observed, can insinuate themselves into the interstices between the particles of water; but when those interstices are filled with any salt, the same water will not any longer dissolve the same salt: but a salt of another kind it will; by reason its particles, being of a different form, will enter and occupy the vacancies left by the former: And thus, again, it will dissolve a third or fourth salt, &c. So when water has imbibed its fill of common salt, it will still dissolve nitre; and when saturated with that, it will dissolve sal-ammoniac, and so on.

*And of saline
bodies,*

2°, It dissolves all saline bodies; it being the constituent character of a saline body, to be uninflamable, and dissoluble in water. Hence water may dissolve all bodies, even the heaviest and most compact, as metals; inasmuch as those are capable of being reduced into a saline form: for these may be so intimately dissolved by water, as to be sustained therein.

*Of saponaceous
bodies,*

3°, It dissolves all saponaceous bodies, *i. e.* all alcalious salts, and oils blended together: Those two bodies make a sapa, which is a saline body, but not a salt. Now oil it self is not dissoluble in water, but the admixture of the salt here, rendering it saline, water readily dissolves it.

All the humours in the human body, are apparently saline, tho none of them are salt it self. The same may be said of the juices of all vegetables, excepting the oils; which, accordingly, dissolve in water.

Salts are the active instruments of nature; and yet these do not act unless dissolved either by water or fire.

A crystal is a glebe of salt, or metal, or both together: If now you take sea-salt, well dried, it will be white, and not transparent; dissolve it in water, and after exhaling the water, it will become transparent, by reason of the water interposed between its parts.

Dissolves glass.

4°, It dissolves glass it self; for this, if melted with salt of tartar, becomes soluble in water.

And gums:

5°, It dissolves all gummous bodies; this being part of the definition of a gum, that it dissolves in water; in contradistinction from a resin. But oleaginous bodies it leaves untouched: nay, and what is more extraordinary, it repels them; and by repelling, drives the oily particles into eddies.

*Does not dissolve oils, or
oleaginous bodies,*

If an hundred drops of oil be thrown upon water, all the several drops, which before were perfectly dispersed, will soon gather together again, and leave the water alone; so that there should seem to be some

some repugnance between water and oil, and some attraction between the particles of water, as also between those of oil. Add, that water seems to repel all oleaginous, fatty, and adipous bodies wherein oil predominates; and hence also it is, that the fatty parts in our bodies escape being dissolved by water. And 'tis, in all probability, by this means that fat is collected in the adipose-cells of all animals.

Nor does water dissolve sulphur; for tho you boil sulphur ever so long in water, it will still remain untouched. *Nor sulphur.*

Nor does it dissolve terrene or earthy bodies, but rather unites and consolidates them; as we see in tyles, &c. Water, however, mixed with acali salts, dissolves oils and oily bodies: thus, tho mere water poured on greasy wool, be repelled thereby, and contributes nothing towards cleansing of the same; yet mix a strong lixivium, or an alkali salt with the water, and it then readily dissolves and absorbs all that was greasy and oleaginous: and thus it is woollen clothes are scoured. But neither will water alone do, as being immiscible with oil; nor will any other sort of salts; for sea-water, with all its salt, will never wash out any oily impurities. So, in the ordinary methods of scouring and fulling, the stuffs are washed in stale, putrified human urine, which is known to be a thorow alkali. *Nor earth. Alkali salt added to it makes it dissolve oil, &c.*

Lastly, it does not dissolve resins; as we conceive a resin to be no other than an inspissated, or concentrated oil. *Does not dissolve resins.*

Concretion of Water into Crystals.

AFTER water has dissolved a body, it grows, and hardens together with it; and if the body be of the saline kind, forms crystals, and retains the salt in that form. Salts, while thus joined with water, assume various figures: the crystals of sea-salt, *e. g.* are pyramidal; those of nitre, prismatical; those of sal-gemma, cubical, &c. But, that water is the cause of those salts being in crystals, is evident hence, that upon separating the water, the crystals are no more; their form is lost, and their transparency ceases. *With salts shoots into crystals.*

Water the great instrument of fermentation and putrefaction.

WATER is properly enough denominated the mother of fermentation, as no fermentation can be effected without it. Dry bodies, in effect, never ferment: thus, if you grind a plant into a dust or *farina*, it will not ferment, even tho you add oil, or spirit of wine, thereto: But pour water on it, and, as if you had given it some new vital principle, it strait ferments, and produces the desired effect. *No fermentation without water.*

The inspissated juice of grapes may be kept a long time without fermentation; but if you dissolve it in water, fermentation soon arises. So that the requisites to fermentation, are, 1^o, Fire, to actuate. 2^o, Air, to vibrate. 3^o, Water, to dilute.

In

Theory of CHEMISTRY.

In like manner, all putrefactions, both of animal and vegetable bodies, are performed by means of water alone; take, *e. g.* a pound of fresh flesh, and keep it in a heat like that of our body, and in a few days the putrefaction will be compleated: but, if you first drain out or exhale all the watry part from the same in some chemical vessel; tho the salt and oil remain; the flesh will harden like a stone, and may be kept for ages without putrefaction. Tho, water poured on it, or even the common dew, will soon set it a putrefying.

By such means, bread, flesh, or the like foods, may be preserved for ages; provided regard be had to the place: Hence it is, that in dry countries, as *Ægypt*, dead carcases never putrefy, but dry and harden uncorrupted; as we see in the mummies found buried under the sand. Even human blood, which naturally is so prone to putrefaction, if you deprive it of its watry part, may be kept for fifty years: goats blood we actually find kept so long in the shops, without corrupting; tho if you dissolve it in water, and expose it to a gentle warmth, it putrefies immediately. So that air, water, and fire, are required to putrefaction as well as fermentation.

Water contributes to effervescencies.

Nor effervescence.

WATER is of absolute necessity to effervescence*, which is an intestine motion arising between contrary salts: now no such motion can arise from a mixture of contrary salts, unless there be water withal: thus sulphur, mixed with steel filings, raises no effervescence, unless water be added; so if you mix acid and alkaline salts together, in a dry form, they will remain without effervescence; excepting such as are themselves impregnated with water, as oil of vitriol and spirit of nitre, which yield water in great abundance. Oil of vitriol is one of our greatest acids, and with a little degree of cold shoots into crystals; tho a gentle fire readily liquifies it again: now, if some of this oil be mixed with a body that has but little water, scarce any effect is seen; but pour on water, and a surprizing effect will be produced.

Water separates oily from saline bodies.

Water also serves in making separations of oily parts from saline ones; which is a thing of the utmost service in chemistry: Thus, any oleagenous substance, mixed and incorporated with a deal of salt, if it be

* An experienced *German* chemist relates, that in some parts of his country, he met with vitriol stones, or marcasites, that, by the action of mere common water, resting for a competent time upon them, would grow so hot, as to enable the liquor to retain a sensible heat, when it had passed a pretty way from them. And many accidents may occasion the breaking out of such waters, or the change of their course in the subterranean places. So,

that common water may, in a very short time, produce considerable heat in mineral bodies, appears by mixing two or three pounds of fine powder of common brimstone, with a convenient quantity of filings of iron; for this mixture being drenched with common water, will, in a short time, grow exceedingly hot, and send out a thick smoke, like that of good quick-lime, while slaking with water.

shook

shook a good while in a sufficient quantity of water, the salts will be extracted from the oil, and dissolved and imbibed by the water; and thus the body is dulcified. So butter, by a continued lotion in fair water, becomes insipid; and aromatic oils agitated a long time in warm water, lay aside their saline, spirituous parts, and become inert and inodorous.

'Tis likewise by water that acid spirits are separated from the bodies dissolved thereby; particularly metalline ones. Thus a metal being dissolved in some acid spirit or other menstruum; if you mix a quantity of water therewith, the menstruum becomes weakened thereby, and lets the metal fall to the bottom. So if you pour water on a solution of gold in *aqua regia*, and then expose it to a moderate fire to evaporate; without melting the crystals, it will carry away with it a great part of the acid spirit, and leave the gold dulcified. *Separates acid spirits from bodies dissolved therein.*

Water, alone, we have observed, has the property of diluting salts, and repelling oils: but 'tis by salts, that the operations of chemistry are chiefly effected; nor can salts act unless dissolved: Consequently water, as it brings salts into action, is of the utmost importance in chemistry. *Great uses of water.*

To this we owe the separations of sulphureous and inflammable spirits: Alcohol of wine, mixed up with oil, makes one body therewith; but if you pour water thereon, it will repel the oil, and draw all the alcohol to it self. Nay, frequently, what alcohol had dissolved in other bodies, water will separate therefrom, by attenuating the alcohol, and letting the other matters precipitate to the bottom. *In making separations.*

Water, therefore, contributes to bring forth the active parts of all bodies; as it extracts their salts, alcohol, spirits, odours and tastes; which it does without any notable diminution of their powers. Hence water becomes greatly useful in making divers extracts, viz. by dissolving the saline, spirituous, aqueous, saponaceous and other matters, and separating them from the rest of the body. *Bringing forth the active principles of bodies.*

In distillation, water is of the utmost use: It is this that receives the active parts of bodies; and in affording them, as it were, a vehicle, it insinuates into their pores, separates the oil, and raises it on high, without making any stench: And thus are the essential oils of bodies distilled without burning, and without being tainted with that empyreuma which is the consequence of combustion. Thus there would be no procuring, e. g. of distilled oil of cinnamon, without water; but such as would have an intolerable stench. *In distillations.*

Salts, and saline bodies, by a repeated affusion of water, are rendered volatile; and even metals are capable of being distilled by the same means: so oil of vitriol, which otherwise does not rise without the most vehement fire, yet, being mixed with water, becomes volatile, and yields an excellent acid spirit, called by *Helmont*, *Acidum Esuriens*. *Volatilizations.*

In fine, water serves good purposes in the dulcifying of bodies: for there are abundance of things to which acrid saline matters adhere, *In dulcifying bodies.* and

and which are hereby rendered sharp and acrimonious; but these acrimonies may be volatilized by repeated affusions of water; *i. e.* be dissolved and carried off; and thus the bodies left fresh and sweet.

Water serves for the Direction of Fire.

Water of use
in the manage-
ment of fire.

WATER is of great service among the chemists, in directing and determining the degree of fire: This was first discovered by *M. Amontons*, from an observation, that water placed over the fire, grows gradually more and more hot, till it comes to boil; but that it then ceases to increase, and only maintains its present degree of heat; even tho the fire were ever so much enlarged, or it were continued ever so long over it: This, then, is a fixed degree of heat all over the world; boiling water, provided it be equally pure, being of the same heat in *Greenland* as under the Equator.

Divers degrees
of heat produc'd
thereby.

By means hereof, therefore, our distillations are much more conveniently managed; and we are enabled to make baths of divers degrees of heat, accommodated to the various occasions: As 1°, A vapour-bath, *balneum vaporis*, where the body to be distilled is placed in the steam of boiling water. 2°, Dew-bath, *balneum rosis*, where the body is likewise placed in the steam, but somewhat nearer to the water than in the former; so that the heat is somewhat greater. 3°, Sea-bath, *balneum maris*, or, as 'tis vulgarly called, *balneum Maria*, where the body to be distilled is put in the water it self, and consequently undergoes a yet further degree of heat than either of the former. 4°, *Balneum ventris equini*, or *fimi equini*, horse-dung-bath, when a body is laid to digest in horses dung; the heat whereof is managed and directed by water: for as soon as the dung dries, it cools; and is restored to its former heat by the pouring on hot water. 5°, Hay-bath, *balneum feni*, when a body is laid to digest in moist hay, whose heat is likewise directed by water.

From what has been said, of the ingredients, properties and powers of water, we may easily apprehend the reason why the antients called it *οινον καθολικον*, universal wine.

of

Of EARTH.

THE earth we here principally propose to consider, is neither that of the naturalists nor the vulgar; but the elementary, or pure virgin earth, allowed for a chemical principle.

The word among the naturalists denotes the terraqueous globe; and *Earth, chemical, what.* in agriculture signifies that compound matter which serves for the production and growth of vegetables planted therein; but the chemical earth differs widely from them both, as being *a perfectly homogeneous, or simple body, hard, friable, insoluble in air or water, fixed, and incapable of flowing in the fire, but remaining immutable, and retaining its own form and quantity in them all.* We term it a fossil, as being *How distinguished from other bodies.* exceeding simple, or inorganic, without any distinction of vessels and juices; and proceeding originally from the common matter of the terraqueous globe. 'Tis called simple, because all its parts appear of the same nature with the whole. We define it hard, because it resists the separation of its parts; friable, because it may be broke into less masses; and fixed in the fire, because with whatever violent degree of heat 'tis every way surrounded, it loses nothing of its weight or bulk, yet without running into glass; but possibly the focus of a large burning concave, may cause some alteration therein; tho it would lose considerably less than any other body in nature, even gold it self; the most violent fire being unable to break the cohesion of its parts, which is a very uncommon property. 'Tis so simple, that tho it enters the composition of all other bodies, yet it self can never be resolved into any different substance. *Helmont* tells us, it will resist the force of the *alcahest*, which would dissolve all kinds of metals; and declares it to be the simplest body in nature next to elementary water; and so indeed it appears to be. These properties sufficiently distinguish it from all the other bodies we know, whether salts, oils, sulphurs, medicinal earths, metals, &c. Chemical earth, therefore, is a very different thing from sand, which appears to be a heap of brittle flints, or small transparent crystals, fusible by fire, and easily convertible into glass. Our definition, also, sufficiently distinguishes this elementary from the mixed or vulgar earth, which contains a large proportion of other foreign matters, as sand, clay, salts, and a mixture of vegetable, animal, and mineral substances, and is almost wholly reducible to salt and oil; a small quantity of our philosophical, or virgin earth, remaining behind.

In effect, chemical earth is either the pure and fixed ashes of all bodies perfectly calcined, or what rain-water leaves behind it upon repeated distillation.

That afforded by the distillation of water, appears to come out of the *How obtained,* air, into which it is raised along with the smoke, and numerous other parts

parts of vegetable and animal bodies, which fly off in effluvia; for tho' this earth be of it self so fixed, yet 'tis easily rendered volatile by fire, when mixed along with other light or viscid bodies*. Perhaps also in Mr. Boyle's method of procuring it by the repeated distillation of fair water, which every time leaves a quantity of it upon the sides of the retort employed in the operation, part of it may proceed from the cement of the glasses, or the dust of the air, which comes in contact with the surface of the water, whilst 'tis poured out of one vessel into another †. And that earth may easily fly about in the air, seems confirmed by those showers of sand so frequent in the deserts of Arabia. But the white matter which thus adheres to the glass, is not pure virgin earth; being saline in taste, and combustible in the fire; whence it contains both salt and oil; of which it may be deprived by calcination, and repeated ablutions in fresh water, and reduced to the purity and simplicity required in chemical principles.

In vegetables.

Vegetables afford our earth in considerable quantities by calcination, and repeated ablution, in pure rain-water; whereby 'tis freed from the sand, salt, and other fæces that are apt to adhere to it, till it becomes white, like chalk, perfectly insipid, smooth and soft upon the tongue, so long as it is thrown upon live coals, unelastic, or incapable of ringing when struck upon, and a fit matter for tests or cupels, wherein metals will fuse, whilst the containing vessels remain unhurt by the fire: this being perhaps the only fixed matter in nature that will not flow with heat. For which purpose 'tis mixed up with fair water, or that wherein flesh has first been boiled, and by moulds fashioned at the pleasure of the artificer; such liquors being free from all fixed salt, afford an excellent glue in this case. If lead, or any other metal, except gold and silver, be long kept in fusion, in one of these vessels, the metal will be absorbed by it, as a sponge drinks in water; but silver and gold will never thus enter the pores of the vessel; which, therefore, may be called the mystic sieve of *Vulcan*, or the actual strainer of the alchemists. Thus were a mixture of gold, silver, and any other metals, to be blown on a test prepared of our virgin earth, the baser metals would sink into it, and leave the nobler alone behind.

* Mr. Boyle, in his curious treatise of *Effluvia*, observes, that earthy matter may be raised in a very considerable quantity into the air; and to this purpose relates from *Agricola*, an account of a shower of rain, which covered the streets it fell upon with clay.

† The great quantity of earth which Mr. Boyle obtained, in proportion to the water distilled, with the probability there is, that if the operation was often enough repeated, the whole body of the water would be thus converted into earth, renders it impossible to sup-

pose the phenomenon entirely owing to the causes here suggested, as some have imagined. The fact is much better accounted for by the excellent author himself, from the known and allowed effects of fire or fuel, which has the power of making new coalitions of particles in bodies, and thence of introducing new forms: and thus alcohol of wine may be reduced to earth, as well as simple water. Mr. Boyle has tried. See his productions on chymical principles, under the article Earth.

After the same manner may our earth be obtained from the foot, or condensed smoke, of vegetables; which is no more than a black volatile coal. This foot, or smoke, is afforded by all manner of woods, not excepting that employed by the *Romans* before the invention of chimneys. Indeed they diligently sought for such wood as would smoke but little; and perhaps it was said not to smoke at all, only because it did not yield a thick, black, suffocating smoke, offensive to the eyes and nose. The earth which foot affords by calcination, is perfectly like that obtained from the other parts of vegetables; being carried up from them by the force of the fire, whilst wrapped up in a viscous oil, which ascends together therewith: so that hence fire has the power to volatilize fixed earth, and send it up into the air; whereof it does not appear to be any original production. Hence the virgin earth obtained from snow, hail, dew, &c. is very probably no other than what was thus carried up into the atmosphere, and there mixed with these meteors.

Mr. Boyle found by experiments purposely made, that the essential oils of vegetables are almost wholly convertible, by repeated distillation, into a black, pitchy matter, which by calcination affords a large proportion of elementary earth. And fixed alkaline salts, as the same great philosopher has also tried, may, by running *per deliquium* in the air, or by repeated solutions in water, and successive filtrations, be converted into the same. Even rectified spirit of wine, he observes, by repeated distillation yields a small proportion of it, and appears in the form of a spot on the glass, from whence the spirit was distilled. And in short, all vegetable productions, as distilled waters, salts of all kinds, oils, spirits, &c. may be made to afford it.

The same may likewise be said of animal substances. Bone-ashes yield *In animals.* it to great advantage; and from them the assay-masters have the matter for their tests, as well as from the ashes of vegetables. The hair also of animals, burnt to ashes in the flame of spirit of wine, afford a very pure earth, and exhibit the *flamina* entire, after being deprived of the more fluid parts. Thus likewise 'tis very observable, that when a man dies in a hot climate, and lies exposed to the open air, his whole carcase is consumed, or carried off into the atmosphere, in a very few days time; nothing but a mere skeleton being left behind, that contains little or no oil or salt, but appears a perfect calx, like the pure elementary earth of vegetables, as if it had already been calcined. And thus in church-yards, or burying-vaults, we shall sometimes find the form of an entire skeleton, found and perfect to appearance, that with the slightest touch crumbles away, and falls into a kind of dust, perfectly insipid and inodorous. Whence we may form somewhat of a conjecture, as to the quantity of earth naturally contained in the human body; for little or none of it will be made to fly off by a degree of heat less than that of boiling water; as I have found by particular experiments. All the juices, and all the several parts of animals,

whether soft or hard, may, by distillation, calcination, &c. be brought to afford this earth, in some proportion; and as the earth of animals is always perfectly the same with that of vegetables, the difference between them cannot be at all owing to this principle*.

And in fossils.

Sea-salt, sal-gem, and all other saline bodies, tho ever so pure, being dissolved in fair water, will, by rest, constantly deposite a terrestrial part, which may be reduced to elementary earth: and, by distillation, likewise they will afford an acid spirit, which lets fall a considerable proportion of the same. Volatile salts also may be made to afford an earth by distillation: thus, for instance, if an ounce of the volatile salt of harts-horn be included in a proper vessel, hermetically sealed, and sublimed with a heat no greater than that of the human body when in health, the saline part will fix itself to the top of the glass, and leave an oil at the bottom, which, by repeated distillations, constantly leaves some quantity of earth behind, till all the volatile part is perfectly gone off, and nothing but elementary earth remains. In short, this earth may, by proper management, be obtained from all sorts of bodies, but with the utmost difficulty, and in very small quantities, from metals; so that some chemists have questioned whether they really contain any at all, tho they freely allow it to other fossils. And, indeed, we want experiments fully to determine this matter†; tho for my own part, I cannot but be of opinion, that earth is that ingredient in the composition of metals, which gives them their fixity, and that durability for which they are principally valued. But it may admit of a doubt, whether this virgin earth is ever obtained perfectly pure and unmingled with oil, salt, and other heterogeneous bodies, from any subject whatever; yet we may certainly gain it much purer than others of the chemical elements. I have now by me the earth of the plant rosemary, which remains perfectly unaltered, after a vast variety of experiments which I purposely made to change it. This great degree of fixedness and immutability admirably fits our earth for the common basis of all mixed bodies, by fixing their volatile principles, and keeping the whole together under its peculiar form. 'Tis certain that fire, water, vulgar earth, salts, oils, &c. once deprived hereof, become totally volatile and disappear, or spontaneously go off into the air. All salts are fixed merely by the earth they contain; separate them from this, and they will get out of the glasses into which you put them, tho ever so closely stopp'd

Its uses in natural bodies.

* To render the earths of the subjects of different kingdoms perfectly alike, the operation must be performed with great exactness, and the other principles be perfectly separated from the terrestrial one, by calcination, repeated solutions in water, filtration, &c.

† The calces of metals are something very different from pure, elementary earth, tho probably united with a proportion thereof. These

are very apt, *per se*, either with a vehement heat to return to metal again, or else to run into glass; which is not the property of pure virgin earth, devoid of salts. The excellent Mr. Boyle, with great probability, shews them to be the magisteries of metals, and has frequently reduced them back from this their disguised state, to that which is natural to them. See his *Discourse upon Fire and Flame*.

with

with cork, and tied down with bladder. Oils, when they deposite their earth, turn into inflammable or vinous spirits: and there is no chemical principle, fixed and immutable, unless it be this virgin, which is disposed to join her self with all kinds of animal, vegetable, and fossil substances, for their common support and safeguard. There are two grand enemies to all these bodies; fire and water; neither of which hath any natural power to alter or destroy the chemical earth; whence this is an excellent common preserver of them all. Thus the solids of our bodies being merely composed of such earth, they can never be destroy'd by the natural agents which are continually at work thereon; and being also distributed among the fluids, or soft parts of animals and vegetables, it greatly conduces to their preservation, and continuance in their natural state: but unless they were thus mixed with, and detained by the elementary earth, they would all presently exhale into the air in the form of effluvia. And possibly all the bodies in the world, if perfectly deprived of their earth, would be turned into mere spirits.

The chemical uses of our elementary earth, are very considerable. *Its uses in chemistry.* We have already observed, that it is this matter of which tests, cupels, and vessels capable of enduring the most violent fire, are made, for the service of alchemists or such as purify metals. And indeed it is the basis of all manner of chemical vessels, unless we are to except those that are made of metals; for all those of particular vulgar earths and glass, have a large proportion of it in their composition; whence their durability and fixedness in the fire.

Our elementary earth is also of great service in chemistry, on account of the property it has to render all fixed salts volatile; which could not be done without its assistance, and is no inconsiderable secret in the art. Thus if sea-salt, for instance, were, in a coated retort, exposed to a violent heat, the salt would thereby be made to flow indeed, but not to lose of its original weight; the vessel would sooner be melted down, and if made of earth, it would sooner be corroded and penetrated by the salt, than the salt would rise in distillation; but mix three or four times its own quantity of elementary earth therewith, and this will prevent its running, and cause it all readily to rise in an acid spirit by distillation. And after the same manner may the salt of tartar, and other fixed salts, be rendered totally volatile; the earth made use of in the operation being incapable of flowing or vitrifying with that degree of heat which serves to raise them. Whence it appears, that elementary earth is the grand instrument not only of fixation, but likewise of volatilization.

A farther use of this earth is made in distillations; when oily or unctuous subjects are to be treated in that way, such as wax, honey, &c. which cannot conveniently be distilled alone, as being very apt to swell, bubble up, and boil over the neck of the retort, and break the vessels by the explosive matter they contain; whence great damage has sometimes

times been sustained. But by the mixture of our earth, or even, in its stead, calcined harts-horn, the powder of bricks, or the like, will effectually prevent any such explosions during the operation; and by breaking the cohesion of the parts of the subject, and keeping them asunder, cause the distillation to proceed regularly, and with all desirable safety. And by this means a body naturally unfit for distillation, may be rendered a proper subject for it. The want of knowledge in this particular, might prove of fatal consequence. In order to prepare the phosphorus of urine, the subject matter should first be reduced, by boiling, to the consistence of honey; but then it can never be distilled, on account of the bubbles which would continually rise therein, unless three parts of earth are first added thereto; after which the operation may be securely carried on to advantage. And the same is to be understood of the distillation of human blood.

Elementary earth, likewise, admirably serves for the purification of salts and spirits from the oils wherewith they are commonly clogged and rendered impure; for it is a great attractive of oil. Having once boiled some bones in *Papin's* digester, till they were freed from their oil, and rendered so soft and spongy, that I could cut them with a knife, like a turnip; they presently grew hard again upon plunging them into oil. Thus any bone-ashes, calcined to perfect whiteness, and reduced to powder, being steeped in oil, will immediately become consistent and hard. This property which our earth has of attracting oil so strongly, fits it for several chemical experiments. Thus, for instance, when the volatile salt of harts-horn is turned yellow by the quantity of oil contained therein, we have nothing to do but to mix it with three or four times its own weight of virgin-earth, and re-sublime it; which will make it appear perfectly white and fine: the addition employ'd, keeping its oil behind, which before tinged the salt yellow. And 'tis no trifling secret in chemistry, to be able thus to purify and separate salts from oils; which is always done to greater perfection, the larger the quantity of the earth employed about it*.

There

* The doctrine of elementary earth here delivered, appears greatly to countenance Sir *Isaac Newton's* notion of the original formation of matter; by shewing that an unalterable solid substance has a real existence in nature. That great philosopher is pleased to tell us, it seems to him, ' That God in the beginning formed matter into solid, massy, hard, impenetrable, moveable particles, of such sizes and figures, and with such other properties, and in such proportion to space, as most conduced to the end for which he formed them; and that these primitive particles, being solids, are incomparably harder than any other bodies compounded of them; even so hard as never to wear, or break in pieces; no ordinary power being able to divide what God himself made one in the first creation. While these particles, says he, continue entire, they may compose bodies of one and the same nature and texture in all ages: but should they wear away or break in pieces, the nature of things depending on them would be changed. Water and earth composed of old, worn-out particles, and fragments of particles, would not be of the same nature and texture now with water and earth, composed of entire particles in the beginning. And therefore, that nature may be lasting, the changes of corporeal things are to be placed

There is also another kind of earth, besides the virgin, used in the practice of chemistry, viz. a particular sort of clay, or potters-earth, whereof chemical vessels are formed: but of this we shall here take no farther notice, having already considered it under earth in general; and shall do it again when we come to treat of chemical vessels.

placed only in the various separations, and new
associations and motions of these permanent
particles; compound bodies being apt to
break, not in the midst of solid particles,
but where these particles are laid together,
and only touch in a few points, *Newton's*
Optics, p. 375, 376.



of

OF MENSTRUUMS.

THERE is nothing in all the art we are treating of, more curious, useful, and necessary to be known, than the doctrine of *menstruums*; tho the subject has hitherto been but imperfectly cultivated: so that, indeed, no part of chemistry lies more in confusion than this. It shall, therefore, be our present endeavour to deliver it with all the fullness and accuracy we are able.

Menstruums, what.

A menstruum is any sensible body, which, being applied to another, intimately mixes therewith, so as to dissolve it, at the same time that it is itself dissolved; the minute parts of both thence coming to be exquisitely blended, and together composing a new whole.

The manner of their action.

Menstruums, therefore, are solvents with regard to the bodies they dissolve; tho in the solution themselves are also dissolved: for all the parts of the solvent are interposed between all those of the solvend, and *vice versa*; the action being reciprocal. Hence a menstruum, tho it may be said to act mechanically, does not act after the manner of saws, wedges, or the like mechanical instruments; because these do not become one with the bodies they divide. A knife, when it separates the parts of a bisket, does not operate as a menstruum thereon; because it unites not with it: but water boiled up with the same, becoming one body therewith, proves a proper solvent or menstruum for it. Every menstruum then, must itself be dissolved in the act of solution; so that both solvent and solvend resolve at the same time: for solvents can act only by interposing every part of themselves, between every part of the bodies they dissolve. And hence it is evident, that all menstruums must needs be fluid at the time of their action; for fluids only are those bodies which consist of small, invisible, moveable parts, that give way to the least force impressed upon them: and such must necessarily be the particles of menstruums, which so easily insinuate into the pores of bodies, and perfectly dissolve them. And thus silver may become the menstruum of gold; for if an ounce of the former be fused with a grain of the latter, all the parts of the silver will be united intimately with those of the gold; and with it compose one mass. Hence we learn, that solid menstruums ought by all means to be dissolved at the time they are designed to act; that the particles of the solvent may come in contact with those of the solvend. Thus when *Aqua regia* perfectly dissolves gold, all the particles of the menstruum come to touch all the particles of the metal.

Their two kinds of action.

It is easy to perceive, from what is here laid down, that there are two kinds of action in menstruums, or that they may either act by the common properties of fluids, as their gravity, fluidity, &c. or by a peculiar and unknown force residing in each particle thereof.

The term *menstruum* seems to have had its rise from hence: *Tully*, ^{Origin of the name.} and some other antient chemists, observing the most kindly solutions to be made, by digestion, with a heat no greater than that of the human body, in about forty days, they termed this space of time a philosophical month: and hereupon called the solvent employ'd the *menstruum*; intimating the body that performed the dissolution by a menstrual digestion. This term, indeed, was at first appropriated to the solvent for the *philosophers stone*; but it afterwards became a general appellation for all solvents.

Now, tho there are no bodies to be found that can perform the office of a *menstruum* in a solid and dry form; whence that common saying in chemistry, *salts act not before they are dissolved*; yet custom has made it familiar to call such dry and solid bodies *menstruums* too, as have the power of dissolving after they are made fluid. We shall therefore divide them all into two classes, the dry or solid, and the moist or fluid.

1. To the tribe of solid or dry *menstruums*, we, in the first place, refer all metals, which are *menstruums* to one another; and perform that office more exquisitely than any other solvents hitherto discovered. Thus, for instance, if a hundred grains of silver were melted with one grain of gold, every single grain of the mass they compose will contain the hundredth part of a grain of pure gold. And unless this was the case, there could be no such thing as the art of *assaying*; which entirely depends upon the supposition, that whenever two metals are fused together, they will be intimately and uniformly mixed: for if such mixed metal were brought to a *say-master* to determine the quantity of gold in it, he would first melt the whole lump, and after it was cold, cut off a grain weight thereof; which, cupelled with lead, or put into *Aqua fortis* or *Aqua regia*, would yield its proportion of silver or gold; by the weight whereof he would determine the richness of the whole lump. And this shews us, that one metal may indefinitely divide another by fusion; for if in the present case, the quantity of the silver were continually increased, whilst that of the gold remained the same, who can set any bounds to its division? And by the same means all other metals are capable of being infinitely divided. Thus quick-silver, which unites with all metals, except iron, will divide them to a surprizing degree of subtilty: so that if a grain of gold were fused with any assignable quantity thereof, it would be uniformly diffused thro' the whole, and blended with the minutest parts thereof. Whence we may learn, that metals are the best *menstruums* for metals; and that nothing can open one metal more than another metal.

2. *Sulphur* also is a *menstruum* with regard to metals: thus quick-*Sulphur*, silver, for instance, poured upon it whilst in fusion over the fire, will be drank up thereby, with a hissing noise; and if they are well ground together in equal quantities, without heat, they will turn to a black powder, or mass, called *Æthiops mineral*; which being sublimed in a glass-

glafs-vessel, and a naked fire, becomes *cinnabar*. In these three operations, the mercury is divided by the interposition of the parts of the sulphur, tho not so subtilly as when it amalgamates with metals.

And if sulphur be calcined with any of the six other metals, they will scarce be perfectly destroyed thereby; but their metalline parts remain mixed and united with those of the mineral. And such a body as this is calcined lead, or iron treated after the manner of Dr. Willis; for the drops which fall from red-hot iron, when sulphur is thrown upon it, participate as well of the metal as the sulphur.

Semi-metals;

3. All minerals also of a metalline nature are solid menstruums, and particularly *antimony*; which dissolves metals with as much ease as fire thaws ice. But there is no method yet known of recovering the metals with which it has once been fused; all of them, except gold, being lost in cupellation therewith: which gives suspicion that it destroys their metalline nature. This is certain, that nothing is better suited to change their nature than antimony; whence I cannot but suspect the *adept* made use of it, as a menstruum, in the preparation of their *stone*. Nor do I believe there is a better way to obtain that secret; at least, were I to go in quest of it, I should willingly begin my inquiries with this property of antimony.

Or salts.

4. Lastly, *Salts* are solid menstruums; for all the known ones, whether acid, alkaline, neutral, fixed, volatile or compound, naturally assume a solid form, when they can be obtained without any mixture of oil or water. Even vinegar may be separated from all the oil that adheres to it, and be converted into a dry and solid salt. Volatile acid salts also may be fixed, and made to appear in their own solid form, by mixing them with their opposites. For example, should an ounce of *Glauber's* very volatile spirit of nitre be mixed with six ounces of oil of tartar, and two of water, and then distilled in a retort, till the remainder became dry; all that appears in the receiver will prove insipid phlegm, and two ounces of dry salt remain at the bottom of the retort, containing all the acid of the nitre. Whence it appears, that the most volatile acids may be fixed and rendered solid, if all their oil and water be driven from them. This, indeed, is exceeding hard to be done in vinegar, because of the large quantity of oil it contains; and hence the difficulty in regenerating *Sennertus's* salt of tartar, so as to prevent its running.

We look upon all salts, therefore, as dry menstruums, tho they appear perfectly inactive, till by the fire, or some liquor, they are brought to flow; and then they will exert their force upon almost all the known bodies. When salt of tartar is calcined to a great degree of sharpness, it will not corrode any very dry substance; but if it be applied to a man's skin, the exhalations of the body will presently dissolve it, and cause it to act as a caustic.

Cementation,
whar.

When salts are attenuated by the vehemence of the fire, and rendered fluid, they enter wonderfully into all kinds of metals; but if used

in a dry form to dissolve them, they are then termed *cements*. *Cement*, in propriety of language, signifies that mixture of water, sand, and lime, made use of to join and fasten together the parts of buildings; but in chemistry we mean by it a dry powder, to be strewed between layers of metalline plates, in order to their calcination or dissolution. This powder is generally composed either of sal-gem, sal-ammoniac, or nitre and brick dust, mixed together: and thus it has the power of destroying almost all kinds of metals, when it is laid between their plates, and kept in fusion therewith; nay, sometimes it even carries them off with it self. But salts act not by way of *cement* till they are brought to flow; for, till they fuse, they produce no effect upon the metal: but to emit fumes, is to be in a fluid; and thus all *cements*, moistened with water, or with urine, act upon metals; for they are thereby made fluid, and whilst they dissolve other bodies, are themselves dissolved thereby.

No dry menstruum can possibly act, unless their parts be in motion; for they must necessarily be impelled against the bodies they are to dissolve: and this *impetus* they may acquire by trituration, humectation, ^{Whence dry} ^{menstruums act,} ^{viz.} ^{By trituration,} and heat. Trituration has a wonderful force to dissolve some bodies, and will render them as fluid as if they were fused by the fire. Thus if you grind the powder of myrrh, and salt of tartar together, they will dissolve each other. By rubbing new and bright filings of iron in a mortar, with double their weight of clean sulphur, the iron will be dissolved, so as by diluting it with water to afford the *vitriolum Martis*. Gold long ground in a mortar, with salt of tartar, will yield a kind of tincture; and rubbed with mercury, in a mortar of glass, it entirely dissolves into a purple liquor, and becomes a most powerful medicine. Dr. Langelotte has wrote a curious treatise of *the great effects of trituration in chemistry*; and describes a peculiar way he employed to grind gold, whereby he could render it as fluid as the fire does, and make an *aurum potabile* by the bare motion of a mill*. And thus dry and solid metals might, by strong trituration, be brought to afford a variety of menstruums.

Humectation is another means of giving force to menstruums; and this may either be natural or artificial, and proceed from water or oil.

* We find in the *Philosophical Transactions*, N° 87, an account of a letter written by this Dr. Joel Langelotte, chief physician to the duke of Holstein, wherein mention is made of his way of grinding gold, and two engines, or philosophical mills, are there described for the purpose; with one of which, in the space of fourteen natural days, he reduced leaf-gold to a dusky powder; and putting it into a shallow retort, placed in a sand heat, he thence obtained, by gradually increasing the fire, and giving a strong one at last, a few very red

drops; which, digested *per se*, or with tartarized spirit of wine, afforded a pure and genuine *Aurum potabile*. The success of this operation, the Doctor attributes in great measure to the salt of the air, which in grinding plentifully mixes and unites it self with the gold: but this particular he then designed to give farther proof of in his account of some uncommon experiments made in the laboratory at Gottorp. By means of trituration he likewise declares he obtained the genuine mercury of antimony.

'Tis observed by *M. Humberg*, that all metals ground with water give an *aurum potabile*. There are many salts which will dissolve nothing at all till they have been moistened with water; and tin cannot be mixed with lead, but by means of it. The air continually abounds with water, by which it runs the salts that are exposed to it; and the humectations obtained from hence are greatly esteemed. In this case, *Geber*, *Lully*, and others of the reputed adept, would say the spirit of the air insinuates into and dissolves the body. Oil also, by humectation, will promote the dissolution of bodies; as is evident in sulphur, which it converts into a balsam.

And heat.

Of that great and general force given to menstrooms, or all natural bodies, by fire, we have sufficiently treated already, in the particular chapter of that grand chemical instrument.

Liquid or fluid
menstrooms,
are either,

There are two kinds of liquid menstrooms; some being general, as dissolving all bodies indifferently; others particular, as having a limited force, so that they work upon some certain bodies only. Of the latter there are eight *Classes*.

Aqueous,

1. *Aqueous menstrooms* make the first; wherein water appears to be so predominant, that they seem composed of nothing else, whereto their solutive power can be ascribed. Under this class we rank, (1.) *Water* of all kinds, as river-water, spring-water, rain-water, distilled-water, &c. And (2.) *Dew*, as 'tis commonly called; which, tho it appears to consist of nothing but water, is really a mixture of a number of bodies, as oils, salts, lixiviums, &c. for these by heat are raised in vapour as well as water, and floating in the air, fall down together with it in the form of dew.

Oleaginous,

2. *Oleaginous menstrooms* come in the second class. Pure oils consist of two parts, a fiery one and a viscous, which wraps up the fire. But many foreign bodies are apt to mix and entangle themselves with oils; whence their power of dissolving differs according to the different natures of the bodies blended with them. Under this class are contained, (1.) *Native oils*, or *balsams*, as found in animals and vegetables; or as they exude out of the earth. Vegetable oils have always something gross, earthy, and aqueous, in their composition; and by reason of the acid they contain, are menstrooms very different from those oils which have nothing of acidity in them. Turpentine spread upon copper, will corrode it, so as to turn it green; but when deprived, by distillation, of the acid parts it contains, 'twill not at all prey upon that metal. Some chemists pretend, that pure oils will dissolve metals; but I find, by repeated experiments, that if they be perfectly freed from their water and salt, they will not touch them. And 'tis from this acid part of theirs, that when rubbed upon iron utensils, to guard them from rust, they, on the contrary, prove instrumental in bringing it on, unless they be first boiled with ceruse to imbibe their acidity. (2.) *Expressed oils*, which differ from the native on account of the manner wherein they are obtained. The most oily parts of vegetables are made choice of for

for this purpose; which being suffered to dry, so that as much of their water and acid may fly off as can possibly escape, the remainder is well bruised and committed to a strong press, that forces out the oil; which by this means seems to be more intimately united with the remaining aqueous and saline parts; whence these become more impure than native oils, perform their solutions accordingly, and easily grow rancid.

(3.) *Distilled oils*, which, if obtained by means of water, are called *essential*; and if without it, whether by *ascend* or *descent*, *empyreumatical*. *Essential oils* always contain a copious acid spirit, that is very penetrating; by means whereof they effect strange solutions. They also have some aromatic parts, upon which their solutive power in good measure depends. By shaking these oils for a long time with warm water, often poured on a-fresh, they part with their acid and aromatic spirit; whence they become soft and unfit for certain solutions. The empyreumatical oils are possessed of an exceeding sharp salt, which gives them their faculty of dissolving. (4.) And lastly, under this class are contained *oils exuding from the earth*, which contain a large proportion of acid salt; from whence they obtain their power of dissolving bodies.

3. *Alcaline spirituous menstruums* make the third class; and these are obtained from vegetables and animals. But to give the clearer notion of them, we must here explain what the chemists mean by spirits; for several very different liquors go under that name. Fluids, in distillation, usually appear under two distinct forms, and are either seen in separate drops, adhering, like dew, to the sides of the receiver; in which case we term them aqueous fluids; or else they trickle down in certain unctuous veins or rivulets; and then we term them either oils or spirits: oils if they refuse to mix with water, and spirits if they do not. Spirits are either inflammable, and not obtainable without a previous fermentation; or unflammable, which may be either alkaline or acid. They are these alkaline spirits which constitute this third class of menstruums; and may be defined subtle, volatile liquors, that run in veins down the sides of the vessel in distillation, will not take fire, but mix with water, and contain some alkaline salt. If these spirits be committed to distillation with chalk, they may be resolved into three principles; for there will first ascend a dry, white, volatile salt; next a large proportion of phlegm; and lastly, when the fire is increased, a small portion of a sharp, volatile, fetid oil. These substances, considered in a state of separation, have names assigned them denoting their simplicity; but in a mixed state, we call them spirits; and from their analysis, they appear to be truly saponaceous. These spirits are obtained, (1) From all the parts of animals, unless we except the milk and chyle, which, perhaps, are not sufficiently ground and attenuated for that purpose. (2) From all plants after putrefaction. And (3.) From the pungent or aromatic tribe of vegetables, as mustard, horse-radish, scurvy-grass, &c. without putrefaction; for these afford a spirit resolvable into the three principles.

principles above-mentioned; and are in no respect distinguishable from the urinous spirits of animals.

Acid spiri-
tuous,

4. *Acid spirituous menstrua* come in the third class. Acid spirits are subtile, volatile liquors, which run in veins by distillation, will not burn in the fire, but unite with water, and have a very sour and pungent taste. Such are the spirit of verdigrease, or *Zwelfer's* alcahest, spirit of nitre, oil of vitriol, spirit of salt, spirit of alum, &c. These spirits consist of a large portion of water, and a little acid salt, as appears upon their analysis: for if oil of vitriol be distilled from double its weight of chalk, it will yield almost its own full quantity of phlegm; which does not proceed from the chalk employed; for this will scarce afford the least water by the most violent fire: whence oil of vitriol appears to contain but a very small portion of acid. These spirits are obtained, (1.) From *vegetables*, either distilled with water, or after fermentation; for all plants distilled with water, afford a truly acid liquor. And the first running of the water obtained by distillation from balsams, is an acid spirit. (2.) From *fossils*; for all fossil salts, as sal-gem, nitre, vitriol and alum, as well as sulphur, &c. borax only excepted, yield acid spirits by distillation. But from animal substances, no acid spirits are obtainable; tho' 'tis possible to extract them from those imperfect animal juices, chyle and milk. *M. Vieussens* assures us, he could gain an acid spirit from urine; which, indeed, he might: but he mistakes in taking that for an animal acid, which proceeds barely from the sea-salt received into the body.

Acid spirits are commonly divided into *volatile* and *fixed*, tho' they all are volatile except oil of vitriol, and spirit of sulphur *per campanam*; and these may easily be rendered so. If oil of vitriol be contained in an urinal, and placed in boiling water, none of the oil will exhale; tho' it then appears by the thermometer to be much hotter than the water; whence it is said to be fixed: but if any part of it happens to be raised, it nearly resembles oil of sulphur *per campanam*. All these spirits, except vinegar, seldom contain any oil or earth. Under this class we may likewise rank some native acids, tho' they are not spirituous; for instance, verjuice, the juice of citrons, lemons, &c.

Inflammable,

5. *Fermented, inflammable spirits* make up the fifth class; that is, liquors exceeding subtile and volatile, which run in rivulets by distillation, mix with water, and are wholly combustible in the fire. All the known vegetables, that do not of themselves turn alkalious, will, when digested and fermented with water, afford these spirits; tho' they never naturally exist in the subjects that afford them; and can never be obtained therefrom without a previous fermentation: nor were they ever, that I know of, extracted from animal or mineral substances. *Helmont*, indeed, relates, that the breath of a man, blown up the *anus*, has taken fire: but if the phenomenon were true, there seems to have been no more in it, than that an inflammable spirit was here produced in the body, from the spirituous liquors received into it. 'Tis also asserted, that the va-

pours

pour ascending from a jakes, has in the winter time been fired by the flame of a candle. But such phenomena seldom appear: and supposing them real, they only shew that human excrements may, by fermentation or putrefaction, have their oleaginous parts so attenuated as to become inflammable.

6. *Fixed alkalies* constitute the sixth class; which are gained from the ashes *Fixed alkalies*, of plants burnt by a vehement fire, that carries off all their phlegm, spirit, and oil. The term *alkali* takes its rise from the word *kali*, by clapping the Arabic particle *al* to it. *Kali* is the name of a plant growing in Egypt, about the mouth of the river Nile, that proves salt upon the tongue; and when burnt in the fire, leaves a copious, fixed salt behind in the ashes. And this is the salt which comes to us from Scanderoon, under the name of *soda*, and is a principal ingredient in glass. These salts, so far as our present experience reaches, are obtainable from nothing but vegetables; for that fixed salt sometimes gained from the excrements, blood, or urine of animals, is not an alkaline but a sea-salt. And from fossils no art could ever yet extract them; for Tachenius was mistaken in saying, that sal-gem, sea-salt, and the like, were partly fixed alkalies. *Fixed alkalies* are discoverable by their obstinately enduring the fire, their corrosive property, their urinous taste, their faculty of turning some syrups green, and their conflict with acids. They are very powerful menstruums, but exert not their force till dissolved; and therefore will not corrode dry bodies. The ways to make them act are three: first, by fusing them in the fire; at which time they appear like oil, and act with very great violence upon some bodies*; secondly, by dissolving them in water; and thirdly, by suffering them to run in the air; which is a much better way of purifying these salts than by dissolving them with water; for if filtered after they have been permitted to flow in the air, they yield no more fæces in water: but after being dissolved in water, they deposite a copious terrestrial sediment if exposed to the air: whence there is no question but they are rendered much more penetrating by being dissolved in the air. When these *fixed alkalies* are fused by the fire, we term them *alkaline salts*; when dissolved in water, *lixiviums*; and when run by the air, *oils per deliquium*.

7. *Compound salts* constitute the seventh class: we define them saline *Compound salts*, bodies, which can neither be called acids nor alkalies. This definition being negative, may seem not to express the nature of these salts; yet it is strictly exact: and whoever bears in mind the general definition of salt before laid down, that of acid, and that of alkali, will from thence conceive a clear notion of a compound salt, from a negation of the two latter. They are otherwise called *sales enixi*, natural, neutral, hermaphroditical, saturated, impregnated, mixed, and adiaphorous salts; because acid salts are called by the chemists male, and the alkaline female;

* As upon sand, for instance, which they thus dissolve so perfectly as to make glass of it.

and

and because *Helmont*, *Tachenius*, &c. thought them composed of acids and alkalies, so put together as to give the appearance of neither. And what confirmed them in this opinion was, that they yielded acid spirits by distillation. Whence they inferred, that the acid salts were here contained in the alkaline, as 'tis their own comparison) a knife is contained in its sheath; which, therefore, being unsheathed by the fire, appear in their own form. To try if there was any truth in this plausible argument, I committed a pound of nitre to distillation, with four times its weight of well-dried potters clay; and upon the earth remaining in the retort, after the operation was ended, poured warm water, to discover whether any salt was left behind; but the water gained not the least saline taste thereby; nor did it manifest any signs of effervescence when spirit of nitre was poured thereon. From whence it appears, that spirit of nitre is not made by any unsheathing of the acid residing in the alkaline cells of the nitre; but by a conversion of the parts that were not acid before, into such as are acid; otherwise the whole body of the nitre could never be turned into acid spirit. We must own, indeed, if oil of tartar *per deliquium*, be poured upon spirit of nitre; salt-petre, or something very like it, will thereby be regenerated: but we must not infer from hence, that this is the way which nature employs to make it.

These *compound salts* are sal-ammoniac, nitre, sea-salt, sal-gem, borax, and the alums and vitriols of all kinds: for these dissolve in water, flow at fire, as long as they retain their saline nature, and are neither acids nor alkalies. Alums are converted into vitriols by a stony matter, and chalk into the same by an acid one; and if an acid lays hold of a semi metal, it turns it to a vitriol *sui generis*: which appears to be the reason why these were called *compound salts*. Add to this, that chemists found themselves able, by their art, variously to compound and transform saline bodies. Thus if you set a parcel of sea-salt, or sal-gem, over a fire, able to exhale its superfluous moisture, and yet not bring it to fusion, and afterwards calcine, decrepitate, and grind it with bole, and place it in a vehement fire; 'twill become volatile, tho before it was fixed; moist, tho before it was dry; acid, tho before it was neutral; and appear in the form of a liquid spirit of sea-salt. Then saturate this spirit with oil of tartar *per deliquium*, and sea-salt will be regenerated, and appear in its natural form, tho made artificially. Once more, pour this spirit of salt upon a volatile animal salt, and there will be presented you a sal-ammoniac, which is neither acid nor alkali, tho made from both. Thus nitre too, which is a fixed adiaborous salt, will, if distilled from bole, yield a volatile, acid spirit, that being mixed with a volatile alkali, becomes fixed nitre again.

Under this class we also range *artificial salts*, of which there are various kinds; and much better adapted to medicinal and chemical uses than those afforded by nature; such is the *Terra foliata philosophorum*, or the regenerated tartar of *Sennertus*; which proves an exquisite menstruum for metals,

metals, and opens them so as to make them afford admirable tinctures. Such also is *Paracelsus's Samech*, or *Tartarus tartarizatus*, by means whereof myrrh, which otherwise proves of such difficult solution, is readily dissolved. Indeed these compound salts are so efficacious, both in chemistry and medicine, that I make no question but universal deobstruents will, at length, be obtained from them: for no part of chemistry lies more open for discovery, nor can a chemist promise himself greater glory or gain from any other quarter, than this wide field of menstrua and remedies.

To this class belong also the *essentified salts*, as they are barbarously called, which consist of an alkaline salt mixed up, (1.) With an expressed oil; as in *Venice sope*, for instance, which is an excellent deobstruent. (2.) With a distilled oil, as in the sope of *Starkey*, which also admirably opens obstructions. And, (3.) With highly rectified spirit of wine, as in the tincture of salt of tartar, which proves a powerful menstruum in extracting the tinctures of amber, myrrh, and gum-lac.

These salts may be differently composed at pleasure, from any subject, whether of the vegetable, animal, or fossil kingdom; and by dissolving them in water, or fusing them by fire, they will be converted into the most effectual menstrua. Thus, if to any fixed or volatile alkali, you add the acid drawn from a saline body, a compound salt will be thereby produced; but if such an alkali be united with an oil obtained either from animal or vegetable substances, 'twill therewith compose a sope, or *essentified salt*, retaining the nature or essence of the oil employed in the composition.

Mr. Boyle promised us a treatise of the *chemical destruction of salts*; and 'tis great pity that he failed to publish it; the knowledge of salts being of the utmost importance. I hope, however, that what has hitherto been said, will convey a clear notion of their natures, differences, and uses. The ancients acknowledged, that without knowing the differences of salts, there was no coming at the *cabinet of secrets*. The moderns openly declare this to be the only key that can unlock the treasures of *Hermes*. And *Helmont* bids us, if we cannot attain to the *alkabest*, learn to render fixed salts volatile; whereby a substitute may be obtained for that universal solvent.

8. Various compositions of the seven preceding classes, make the eighth and last class of particular fluid solvents; tho it may admit of a doubt whether more than three of them can at once be mixed to equal advantage. Thus if *Starkey's sope*, which is made of the athereal oil of turpentine, and purified salt of tartar, be exquisitely united with highly rectified spirit of wine, the active principles of the composition, namely, the salt, oil, and spirit, retain their full force; but if more ingredients were added, 'tis a chance that the virtues of some of them would be prejudiced thereby. However, the manners of varying and differently compounding of them are endless. And here I cannot but wish that menstrua of all kinds were severally applied to the human calculus;

for I think there is some reason to hope that its solvent may be discovered. There are bodies in nature that act after a peculiar manner in conjunction with others: thus that subtile alkali, spirit of urine, being united with rectified spirit of wine, makes the *offa alba* of *Helmont*; a menstruum so powerful as to dissolve various bodies, which without it were insoluble.

The nature of
the action of
menstruums.

1. From what we have here laid down of menstruums, it appears, that none of them can act, unless first put into motion; and that they produce not their effects by any irradiation, as *Helmont* would have it. A load-stone that is absolutely and in all respects at rest, could never surely act upon iron; but must, by a near approach thereto, have its parts put into motion: and if this be the case in a magnet, with much more reason may the like be allowed of menstruums.

2. Some menstruums have a principle of motion within themselves, whereby they are determined to run into the embraces of particular bodies, and dissolve them; the motion of the solvent and solvend being reciprocal, according to Sir *Isaac Newton's* doctrine of attraction. And indeed it does appear from physical observations and experiments, that the Creator has not only established mechanical principles, whereby bodies in general are moved; but also given a particular structure to some, which remaining entire, is the cause of operations in them, that they would not otherwise manifest: whence it is that load-stones attract iron, and electrics lighter bodies, tho without dissolving them.

3. Other menstruums are brought to act by a foreign force impressed upon them; which may be deriv'd, (1.) From fire; a higher degree whereof will cause a menstruum to dissolve a body it would not otherwise touch. Thus in a very cold season *Aqua fortis* will not work upon silver; tho the natural heat of a man's hand might excite it to action. (2.) From water, which quickens the action of menstruums by dissolving them. (3.) From the air, which by its heat, motion, vapours or effluvia, may stir them up, and add to their force. (4.) From triture, of which there are three kinds; for it may be exercised between solids and solids, between fluids and solids, and between fluids and fluids.

4. But it is not every menstruum, tho ever so violently agitated, that will dissolve every body; particular bodies requiring appropriate menstruums to separate their parts. *Aqua fortis* will not dissolve gold, tho made to boil upon it, nor *Aqua regia* silver; yet the latter menstruum easily dissolves gold, and the former silver. On the other hand, there are menstruums which scarce manifest any motion at all when applied to bodies, yet dissolve them thoroughly. Menstruums, therefore, do not act by their acrimony, or the other common properties of bodies; but there must be some particular and secret relation between the solvent and the solvend, which can only be found out by experiment.

If a quantity of *English* chalk be put into water, the water will not dissolve it, even tho made to boil, and tho a strong, fixed alkali be added thereto; but if you drop a little vinegar upon them, the chalk

will presently begin to fall asunder, and by pouring on of more, be turned to a watry liquid; lastly, add a little salt of tartar, and it will precipitate the chalk into a calx. Whence we have another clear example, that the vehement motion of a menstruum will not always enable it to act; and that some other principle is required to fit it for action. Every natural body must consist of certain minute parts, that are not *physically* divisible into smaller; for we are not here concerned with the *mathematical* conception of infinite divisibility. Thus if a grain of gold were divided into a thousand equal parts, each part would still be gold; and if every one of those parts could be again divided into a thousand others, each of these would still be gold, and a certain portion of the original grain. And if this division be not subtil enough, it might be carried on farther, till at length we arrived at the smallest physical particle, beyond which it could not be divided by any natural power; as having no pore, and being too small to receive the external force of other natural bodies, so immensely larger than it self. This smallest physical particle, I, with *Democritus*, call an atom; not that it is absolutely incapable of any farther division, but because no external physical force can resolve it. Now this atom must have some surface and some figure; supposing therefore there were two of them alike in all respects, and for instance cubical; if these should be clap'd together, so that their two opposite faces perfectly touched in all points, without leaving the least pore between them, then 'tis plain that no menstruum could possibly separate them; as being unable to enter where there is no pore: but if these two corpuscles were set together, so as to leave pores between their junctures, a menstruum fitly disposed, might slide in thereat, and effect a separation. Hence it appears, that menstrooms cannot act, unless they be in contact with the bodies they are to dissolve; nor then neither, if they do not communicate some motion to these bodies: consequently the action of solution is the removal of the parts of a body from their former cohesions, at the same time that they are kept asunder, and not suffered to fall into cohesion again.

The action of menstrooms, therefore, depends first upon their insinuating themselves between the parts of the bodies they are to dissolve; and secondly, upon the agitation given thereto. But to clear this up the better, we must observe there are two things requisite to the cohesion of the parts of bodies; *viz.* that their surfaces be in contact, and that the parts be compressed towards, or be mutually attractive of each other. Bare contact could never cause cohesion; some other power, as either compression or attraction, is absolutely requisite thereto. Every solution, therefore, is the destruction of this contact of parts, and the suspension of their attractive force, or that power which tended to compress them together. But this requires that the solvent should insinuate it self between the parts of the solvend, and shake them on all sides till it overcomes the force wherewith they cohere together; and by throwing them off to a certain distance from each other, prevent their

contact, and the exertion of their attractive power. And such, in effect, is the action of all menstruums; nor can bodies be dissolved by any other means in nature. Hence appears the reason why all menstruums cannot dissolve all bodies: for if the pores of the body to be dissolved are so small, or so disposed, that the menstruum cannot find entrance thereat; and if they prove so wide that the menstruum passes them with too great ease, no solution can possibly follow. And this shews us the difficulty, not to say impracticability, of finding an universal solvent, such as the alcahest of *Paracelsus* and *Helmont*.

The conditions
requisite to the
action of men-
struums.

There are four *conditions* required in menstruums, to render them capable of dissolving bodies to perfection.

1. The first is a due proportion between the size of the corpuscles of the menstruum, and the pores of the body to be dissolved thereby: for if the particles of the menstruum are too small and fine, they may be easily transmitted thro' the pores of the solvend, without producing their effect: and if they were too large, they could not gain admittance between the parts they should separate. And hence it is that saline menstruums reduced to the consistence of oil, will scarce act at all upon those bodies they would otherwise eagerly fret asunder. Thus the strongest spirit of nitre will not touch silver, till diluted, or weakened, as they term it, with water; but then thoroughly dissolves it. The same menstruum will not touch lead before it be let down with twelve times its quantity of water; and oil of vitriol will not corrode iron without a proportion of that weakening liquor. And this lets us see the great mistake of those who think all menstruums dissolve the better, the purer they are made, or the higher they are rectified.

2. The second qualification is a determinate figure of their corpuscles with regard to the pores of the solvend: for the pores of different bodies are differently figured; and consequently require particles of suitable figures to enter them. And this may be a reason why the same menstruum is not able to dissolve all kinds of bodies; and why some menstruums, by a change made in the figure of their particles, lose their power of dissolving. Thus oil of vitriol, by being digested with spirit of wine, becomes unfit to dissolve some metals; and spirit of nitre, which either alone, or diluted with water, dissolves all metals except gold; will touch none of them after 'tis dulcified, as they call it, by being digested with spirit of wine; but, upon silver, for instance, only gains a red tincture. Thus also spirit of salt, or *Aqua regia*, treated after the same manner, will not dissolve gold, but only grow yellow thereon. And *M. Homberg* has observed, that by long continued digestion, with fire, the strongest acids will lose their solutive virtue: but digestion seems to be no more than a continual triture, whereby a change is brought upon the parts of the bodies digested. On the other hand, we find by *Mr. Boyle's* writings, that many bodies have, by digestion, acquired the faculty of dissolving, which they had not at all before. Thus the globules of quick-silver, being of themselves
round,

round, and consequently unfit to corrode bodies, acquire *Spicula*, or sharp points, from *Aqua fortis*, if dissolved therein; which render it an unsafe internal medicine. Spirit of salt will not dissolve crude mercury; but, as Mr. Boyle observes, if the mercury be first dissolved in spirit of nitre, and afterwards reduced to a calx by the fire, this calx will easily open to the former spirit. From all which, we conclude that a change of figure either in the component parts of the menstruum, or the pores of the solvend, may or may not determine the action of the two to solution.

3. The third qualification requisite to the action of menstrooms is solidity and stiffness of parts. The solidity of a body is known by its weight, as we learn from mechanics; and the heavier the matter, the greater, *ceteris paribus*, is its moment or motion; and the stronger its action.

The relative rigidity and solidity of parts between the solvent and the solvend, may exceedingly vary the force of menstrooms. The writers of mechanics suppose their instruments, as levers for instance, inflexible, or infinitely stiff; which makes their force and strength the greatest that is possible: and this stiffness depends upon the immutability of their figure. Now a body that is stiff acts very differently from one that is flexible. A knife of brass, or lead, will not cut like one of steel or iron. We have an instance of the great force of the rigidity of particles from what we take in at the mouth; which we call alimental, if it proves so yielding that its nature may be changed into ours, by the force residing in the body; if what we receive this way has only that stiffness as to cause some change in our bodies, at the same time that it self is changed thereby, we call it a medicine; but if it proves so rigid as to be insuperable by the natural actions of the stomach, intestines, &c. and alters the body to its destruction, we properly term it a poison. Rigidity will cause an impressed motion to be communicated with the greater force; and its quantity is known in bodies by the greater or less resistance they make to a change of their figure, and their degree of mutability.

This doctrine holds true of menstrooms; and therefore, as metals are the stiffest bodies in nature, 'tis impossible to dissolve them kindly by any thing but metals. Tho mercury be dissolved a thousand several times in *Aqua fortis*, it always appears the same upon reduction; and gold will for ever remain unchanged. And hence it is, that no vegetable or animal menstrooms can resolve metals into their first principles. Whence those sayings so common in the mouths of chemists, 'Metals are only acted upon by metals; mercurials are dissolved only by mercurials; metals open to nothing but the matter whereof they are composed, &c.' And hence it was the elder *Helmont* declared, that 'All menstrooms which exert any force upon metals, only exhaust their strength, and weary themselves out thereon, without effecting a thorough dissolution.' The most powerful and rigid menstrooms, therefore, are obtained from the fossil kingdom; the next powerful after these from the vegetable;

table; and the weakest, softest, and most changeable of all, from the animal kingdom: but salt of tartar, the product of a vegetable, is by the elder *Helmont*, substituted even for the *alcahest*. *M. Homberg*, by a course of digestions, continued for several months, found that menstrooms obtained from fossils, as oil of vitriol, oil of sulphur *per campanam*, spirit of nitre, spirit of alum, &c. long remained unaltered; that those from vegetables, as verjuice, vinegar, and the like, were soon changed and weakened; but those from animals soonest of all.

4. The fourth and last qualification, is a fit disposition of the corpuscles of the menstruum, when received into the pores of the solvend, to make some stay there, and not immediately pass thro' them, but act every way upon the body, as they move toward the external surface thereof. Unless this were the case, no solution could ever be made: for if the particles of a menstruum, when received into the pores of the solvend, were not to move forwards, they would constitute one body therewith; whence no separation of parts could possibly ensue. There is, therefore, requisite to this action, some cause able to drive on the particles of the menstruum, after they are admitted into the pores of the solvend; tho not with a free and easy motion. This impulse may proceed from the air, triture, &c. but perhaps principally from the never-ceasing action of fire; for all other bodies, if singly considered, or as having a separate and independent existence, must remain at rest for want of an attractive power to excite them. Thus even water would be a moveless body, were not the fire contained therein to agitate its parts, and keep them in a flux; for deprive it of this, and it will immediately be converted into solid ice. Now, fire exerts but little action upon uniform and perfectly smooth bodies; as gold, from the great homogeneity of its parts, scarce suffers any alteration by it; whilst wood, for the contrary reason, has a great change made in its parts thereby. Whence we may infer, that the corpuscles of a menstruum ought so to be struck into the pores of the body to be dissolved, that some dissimilitude, difference, or heterogeneity of parts, may thence arise; as would happen if the particles of the menstruum entered the pores of the body with one end, whilst the other stuck out above its surface: in which case, the fire, by striking upon all the extant parts, would wedge them in farther, and thereby effect the dissolution. But if the whole particle should at once enter, so as to constitute one homogeneous body with the solvend, no dissolution would thereby be procured. And this gives us the reason why heat, tho in general it promotes dissolution in bodies, by causing the ambient fluids to impinge with the greater force upon the extant parts of the menstruum, may, in some cases, prove an impediment thereto; by driving the corpuscles of the menstruum so far into the pores of the solvend as to leave no part of them extant, or exposed to the force or agitation which should bring about the solution. Thus the flowers of zink, when boiled in vinegar, remain untouched therein, like so much sand; yet will presently dissolve, if the vinegar be poured

poured on cold: the same also happens in a mixture of iron and tin; whence, possibly, zink is a composition of those two metals. On the other hand, there are some solutions that require the assistance of heat; for instance, spirit of nitre will not dissolve mercury without it. But it is not strictly true, we see, that all solutions will be the better performed, the greater is the heat employed to make them. Dissolutions are carried on in the greatest perfection, when the corpuscles of a menstruum, received into the pores of the solvend, are resisted by the way; yet continue moving, tho slowly, forwards. Upon the whole, it appears, that every menstruum requires a certain size, gravity, and motion of its parts, to determine it to action; after being applied to the body whereon it is designed to act. This application is made by means of gravity, without which one body could never be applied to another; but this gravity varies with the quantity of the atmosphere concerned: whence salts cannot be made to act as solvents in the exhausted receiver; and all things lose their taste upon the tops of very high mountains.

From what we have hitherto laid down of menstrooms, we may draw this general conclusion; that as the primary elements of bodies are never dissolved, all the chemical solutions, made by means of menstrooms, reach no farther than to separate one primary element from another; the particles of the first composition being absolutely solid, with regard to chemical operations; since their pores, if they have any, are impervious to the finest particles of our solvents; on which account, they may, with regard thereto, be well enough supposed to have none: for there must of necessity be a certain proportion between the particles of the solvent, and the pores of the solvend. I cannot recollect any experiment whereby either fire or air appeared to be changed; and some will question whether the particles of water are capable of alteration, if, by any means, it could be obtained perfectly pure. It should seem to me, that God originally divided matter into numberless particles infinitely small, and uncapable of any farther alteration or change by the established powers of nature; and that the resolution of bodies into these original corpuscles, is the utmost effect of chemistry; beyond which it cannot go, in the business of solutions*. But these elementary corpuscles only seem incapable of farther change or separation of parts, because they are perfectly solid; or at least because their pores are too small to be entered by any bodies in nature. Thus pure oil of vitriol will not touch iron, nor spirit of nitre silver, till diluted with water; whence it evidently appears, that the saline corpuscles of the

General conclusion from the preceding doctrine.

* Sir Isaac Newton seems to be of opinion, that even the smallest cluster, or most simple composition of these primary particles, if not the primary particles themselves, may be dissolved by means of fermentation; and that if the original corpuscles, or primary particles of

gold, for instance, could once be brought to ferment, whereby they would be broke into still finer particles, that metal might be changed into any other body in nature. *Vide apud Harris Lexicon Technic. in Initio.*

oil,

oil, or spirit, were at first too gross to get in at the pores of the metal; which they were enabled to enter, when dissolved and broke into finer *spicula* by the water. That the menstruum, in this case, really enters the pores of the metal, appears from hence, that if a dram of silver be put into an ounce of strong spirit of nitre, diluted with a due proportion of water, the dissolution will immediately be effected; after which, if the water be evaporated or drawn off, it will prove insipid upon the tongue, and leave all the acid behind, united with the silver, into a mass of thin, separable plates, which are strongly corrosive. Whence it is manifest, that the acid of the nitre, which, by the assistance of the water, dissolved the metal, entered, and so strongly fixed it self in its pores, as not to quit them with the water that was afterwards drawn off. And this remaining mass, being dried and fused, becomes the *Lapis infernalis*.

The corpuscles of every menstruum are, therefore, to be considered as a parcel of small wedges, of a determinate figure, size, stiffness and gravity, driven by the pressure of the air, or the action of fire, with a certain force, into the pores of bodies; which, if they pass not too freely; they dilate, raise, disjoin, shake asunder, and throw off their parts; break their cohesions, and prevent their returning into them again. And thus we have mechanically explained the actions of menstrooms; but there are other effects of them not yet reduced under this obvious notion: the principles of their motion remaining utterly unknown to us, tho we are acquainted with the laws thereof.

Corollaries from
the actions and
conditions of
menstrooms.

It will here be convenient, by way of corollary, from the doctrine hitherto delivered of menstrooms, to give the several particulars it leads to.

1. And first we may see that motion alone is not the cause of the dissolving power in menstrooms.

2. That we cannot judge of their force *a priori*, or from the manner wherein they affect our senses, or the organs of taste, touch, &c. for corrosiveness to the tongue, or other parts, is no proof of a solutive power with regard to other bodies. Experiment alone can inform us in this point: 'tis this which shews us that *Aqua fortis*, tho it eats into the flesh, will not touch gold, yet readily dissolves the other six metals; that oil of tartar *per deliquium*, tho it corrodes many parts of the human body, is a preserver of the teeth, if used with caution; that *Aqua fortis*, tho fiery, and vehemently corroding upon the palate, will not touch wax, tho it presently frets metals asunder; that oil, tho almost insipid, scentless, and scarce capable of giving pain, even when applied to the eyes, will make a thorough solution of sulphur, which neither *Aqua fortis*, *Aqua regia*, spirit of salt, oil of vitriol, nor Mr. Boyle's *menstruum peracutum* would effect; that air and water, tho perfectly tasteless, fret iron into rust, copper into verdigrease, and dissolve salts, which the highest spirit of wine, that burns the mouth, will not touch; and lastly, that so innocent and harmless a spirit may, by bare distillation, be gained

gained from common bread, as to be drank with safety, or poured into wounds without causing pain; which is yet so powerful and wonderful a menstruum, that it will dissolve stones, as Mr. Boyle discovered.

3. That the hardness or strength of a body neither retards nor promotes its dissolution. Pure gold, that has been refined with antimony, is so soft, that it cannot be worked alone; and steel, artificially tempered, so hard, that it will cut such gold in pieces; yet any common acid will dissolve the steel, but not touch gold: and by means of a slender thread, drenched in such an acid, may the strongest iron-bars be dextrously cut or sawed asunder. We cannot, therefore, say of a menstruum, it is *weak*, and consequently unable to dissolve *hard bodies*; nor because a menstruum dissolves *hard bodies*, that it must, therefore, dissolve *soft ones*; for we experience the contrary every day. *Aqua fortis*, which is capable of fretting metals and stones asunder, exerts no force at all upon wax; wherewith, if any vessel be lined, you may therein preserve the most volatile and corrosive liquors, as well as in those of glass. Vinegar, which may be applied to the soft parts of the body without prejudice to them, will yet corrode the bones, the teeth, and coral, into brittle plates or shavings; and iron into a crocus. Coral, whose tincture the most violent menstrooms will not extract, easily parts with its fine red colour to new milk, upon being boiled therewith; and thereby becomes white it self. And lead, tho a soft body, will not yield to the strongest acids; but readily opens to the juice of lemons, or spirit of nitre, diluted with twelve times its quantity of water.

4. That we cannot from particular instances of corrosiveness in a menstruum, argue its solutive power in the general; for we frequently prefer a reputed weak menstruum to a stronger. Thus, tho oil of almonds be esteemed so feeble or mild, and rectified oil of vitriol so powerful and corrosive a solvent, yet sulphur will be entirely taken up by the former, but remain untouched by the latter. And wax, as was before observed, will be in no wise prejudiced by the most violent and corrosive liquors; which gives us leave to hope, that tho the human *calculus* has hitherto resisted the force of the strongest alkaline and acid menstrooms, yet a proper one may be found to dissolve it, by injection, without hurting the bladder wherein 'tis lodged: the hardest of common stones are dissolvable by liquors that will not touch some other bodies; why, therefore, may there not be prepared a menstruum capable of dissolving the stone in the bladder, without prejudicing the part that contains it? Various solutions are performable in vessels of glass, and those of other substances, if defended on the inside by wax; without the least damage to the vessels, or their lining. From all which particulars, it plainly appears, that the powers of menstrooms are only to be determined by experiments. It will, therefore, be convenient to lay down from experiment the laws of their action, and add some rules for their direction and management.

Laws observed
in the action of
menstruums.

1. *Alkaline menstruums, whether fixed or volatile, dissolve most of the bodies which acids do not meddle with.* Thus every alkali, as spirit of hartshorn, spirit of human blood, &c. so thoroughly dissolves sulphur, which no acid will touch, renders it so easy to mix with water, and breaks and grinds its parts to such a degree of fineness, that it is never reducible to sulphur again. And this holds true of every sulphur.

2. *Acid menstruums, whether volatile or fixed, dissolve most bodies that prove insoluble by such as are alkaline.* Thus all metals are dissolvable by acids, and none of them, except copper and iron, by alkalies. Crabs-eyes dissolve readily in acids, but scarce unite with alkalies. Oil of tartar per deliquium will not corrode, but gives whiteness to the teeth and bones that are sound, and is therefore used in the preparation of skeletons; but *Aqua fortis*, vinegar, or other acids, would presently dissolve them. And hence it is that acids commonly set the teeth on edge, namely, by beginning to corrode them. 'Tis, therefore, a very ill practice to clean the teeth with acid preparations; which, as they take away the roughness and leave them white, eat away their substance, as we find by the practice of empirics, who venture to make use even of oil of vitriol, and the like, for that purpose.

3. *All acids have not equally the power of dissolving all bodies; but some dissolve one body, and some another.* Thus vinegar excellently dissolves lead, which *Aqua fortis* will not do, unless with water it be let down to the strength of vinegar. *Aqua fortis* dissolves all metals except gold, which it cannot be brought to touch. And the same is to be understood of alkalies.

4. *Every spirituous menstruum has a peculiar subject whereon it operates, which will not open to another.* And the same holds true of all kinds of solvents, according to the various classes under which they are ranged. We shall assign to each its proper objects, in the following rules for the ordering and procuring their solutions.

Rules for the
management
and application
of menstruums.
And first, to
prepare sol-
vents for sol-
vents.

1. 'Tis the office of some menstruums to prepare the way for the operations of others, which would otherwise have no effect upon the bodies they were designed to dissolve. Thus alkaline menstruums digested with sulphur, render it soluble both in spirit of wine and water, wherein it would, without such digestion, be absolutely irresolvable. Mr. Boyle relates a great number of experiments, whereby he in vain attempted to extract the tincture of sulphur: but Dr. Wallis has a method of doing it, by first opening the body of the sulphur with salt of tartar; whereby he obtained a very rich tincture. Thus metalline ores, and antimony, will, when opened with alkaline salts, yield a tincture in spirit of wine. But no sulphureous and bituminous bodies, tho' boiled ever so long in aqueous liquors, will be brought to unite therewith, unless they be previously opened by alkalies. None of the metals, besides copper and iron, will yield to alkalies; but if any of them, as silver, for instance, should first be corroded by an acid, then crystallized, and afterwards reduced to a calx, this calx will readily open

open to alkalies, and be exceedingly changed by digesting with the fixed kind thereof. And upon this foundation it was that *M. Homberg* advanced and experienced a method of resolving metals into their first principles; for alkalies, by absorbing and drinking in the sulphureous part of metals, leave their mercury behind. Hence it appears, that acids and alkalies may mutually assist each other in the resolution of bodies; which is a great and useful secret in chemistry.

2. *Aqueous menstruums* take up, (1.) From the *vegetable kingdom*, all manner of salts, spirits, saponaceous and gummy bodies, properly so called; but unite not with oils, rosins, balsams, pitch, colophony, and earth. (2.) From the *animal kingdom*, salts, spirits, saponaceous and glutinous substances, which are only animal juices boiled to that consistence; but not such as are fat, unctuous, or earthy. (3.) From the *fossil kingdom*, salts, and any saline, aqueous, or saponaceous body (for saponaceous earths have been lately discovered) and a few of those that are bituminous; but touch not such as are oily, sulphureous, metalline, stony, earthy, and abundance that are bituminous. But all this is to be understood of menstruums purely aqueous; for if other bodies be mixed with them, their action will be altered thereby. Thus, for example, if rain-water has any mixture of salt, it will corrode iron and copper, which it would not touch if it were pure.

3. *Sulphureous and oily menstruums* will not of themselves act upon any things that are aqueous, saline, or earthy; but only on such as are sulphureous and oily, viz. sulphurs, pitch, bitumens, rosins, and the like. Thus sulphureous menstruums dissolve the spirituous and oily parts from vegetables, but leave the others untouched: and oils boiled up with the same, extract only their odour, and more subtle virtues. Spirit of turpentine, however, thoroughly dissolves the harder gums, as that of copal and caranna, and thereby makes the most beautiful varnishes; tho these gums thus yield to no other oil or salt. These menstruums also dissolve no subjects of the animal kingdom, but such as are oily, sulphureous, or unctuous; and nothing but bitumens, sulphurs, amber, and jet, from those of the fossil. Admirable tinctures are extracted from fossils by oils: thus by digesting oil of turpentine for a month, upon antimony reduced to an impalpable powder, we gain a fine red tincture, of great virtue in the leprosy and all foulnesses of the blood; tho it scarce differs from the tincture of common sulphur, obtained with the same menstruum; as being given by the sulphur of the antimony, which in reality is common sulphur. And thus oil will draw an abominable tincture from cobalt, by uniting with the arsenic it contains. Whence we may conclude, that all oils which grow red upon bodies, do so by dissolving their sulphur.

An experiment related by *Mr. Boyle*, has led some people into a belief that oils are solvents for copper; tho he only tells us, if pure oil-olive, newly imported from *Italy*, be without farther preparation applied to that metal, it will corrode the same, and grow green thereon.

But this solutive power proceeds merely from the vegetable spirit where-with that oil constantly abounds; for if the same oil be thoroughly purified by means of salt of tartar, it will have no such effect upon copper. And the same spirit it is in oil, that makes it appear to corrode iron.

For the inflam-
mable spiri-
tuous.

4. *The most pure and inflammable spirituous menstruum*, called *alcohol* or *exquisitely rectified spirit of wine*, unites with, or dissolves all aqueous, saponaceous, unctuous, and resinous bodies; but meddles not with salts, earth, and sulphur, tho it drinks in the other fossil oils.

For the alka-
line men-
struums,

5. *Pure alkalies*, whether volatile or fixed, dissolve all aqueous, saline, and saponaceous bodies, as also whatever is coagulated by acids; great numbers of which kind of bodies they, therefore, make fluid. They likewise act upon sulphureous and oleaginous bodies, either by decoction, digestion, or distillation; and bring metals into a fluor, if first opened by acids. They moreover exert their force upon all gummy and resinous subjects, and open them so as to render them easy to mix with water, and capable of yielding their tinctures to spirituous menstruums. Thus pure spirit of wine will readily extract a tincture from myrrh, or gum-lac, if they be first opened by salt of tartar; tho it could hardly be gained by any other means whatsoever. But it must here be remarked, that many vegetable ingredients will be so scorched up by alkalies, made too strong for the purpose, as scarce to yield any tincture at all. Thus, if in preparing *Elixir proprietatis*, strong oil of tartar be, by it self, poured upon the aloes, myrrh, and saffron, they will be burnt up thereby, and not give colour to the medicine; but if that oil be diluted with water, before 'tis put upon the ingredients, the operation will be performed to great advantage. The same thing holds true in extracting the tincture of gum-lac; for unless the oil of tartar be here diluted, it will burn the gum, as it were, to a coal. And thus fixed alkalies are of admirable use in preparing bodies to admit the actions of some solvents. Boil sulphur ever so long in water, and it will not be dissolved thereby; but add a little salt of tartar to the decoction, and a perfect solution will presently ensue. And by means of this contrivance, water may be made to take up many bodies that it would not otherwise touch. Oils will unite with alkalies, and by that means constitute sope; but pure inflammable spirit refuses to meddle with alkalies; yet having the property of dissolving oil, it also may be made to dissolve the alkali contained therein. 'Twere a very difficult task directly to dissolve sulphur in pure spirit of wine; but 'tis easily done, by first boiling the sulphur with an alkaline salt, or dissolving it in oil, and then digesting it with the spirit. By thus making use of an intermediate menstruum it was that a crafty chemist imposed upon the Bishop of *Cologn*, by selling to him a sham tincture of gold, at an exorbitant price. This artist took, suppose, half an ounce of gold, and two or three ounces of antimony, fused them together into a brittle mass,

mass, and afterwards ground them into an impalpable powder, which he, for a long time, digested with a fixed alkali, run *per deliquium* in the air, and afterwards with pure spirit of wine; and the liquor afforded by the process he called tincture of gold, or *Aurum potabile*. But it was easy for those to have discovered the cheat, who knew that antimony contains a sulphur, which being melted with gold, renders it brittle and pulverable; and that all sulphurs, if dissolved by alkalies, are thereby rendered soluble in pure spirit of wine, which will not thence be enabled to take up a metal; so that the gold here remained at the bottom, and might easily be reduced to its pristine form; the liquor swimming over it being only a bare tincture of sulphur, which would entirely evaporate by heat.

6. *Acid menstrua* join themselves to, and consequently dissolve all kinds ^{For the acid.} of aqueous liquors and ardent spirits, as may appear from the manner of dulcifying spirit of nitre and spirit of salt; and mix so intimately with all oils, as therewith to afford true, artificial sulphur; as we evidently see from that which is produced upon the union of oil of vitriol and oil-olive. They likewise fret asunder, split, crack, dissolve, or reduce to powder, all kinds of earths, stones, gems, *calces*, testaceous and petrified bodies, bones, corals, the human *calculus*, tho this be performable only by spirit of nitre; and lastly, all the metals: so that there is scarce any thing able to withstand their force. No wonder then that *Hannibal* could break rocks, and gain a passage for his army over the *Alps* by means of them. And by means hereof it is, that the magisteries of pearls, crabs-eyes, &c. are made; for after the dissolution is over, 'tis easy to precipitate those substances out of the menstrua, by adding a fixed alkali thereto. Acid menstrua are of three kinds, being either gained from minerals, crude vegetables, or vegetables after they have been fermented.

1. *Mineral acids* are those of sea-salt, sal-gem, nitre, sulphur, alum, vitriol, and antimony, which contains an actual sulphur, exceedingly like the common; whence proceeds its acid. All these acids, except that of sulphur and antimony, are different from one another; and according to *M. Homberg*, all salts do not participate of the same acid. Spirit of sea-salt dissolves gold, which other acids will not touch; spirit of nitre shakes the parts of the human *calculus* asunder, tho no other acid will do the same; spirit of sulphur will not work upon silver, which yields to all the other acids, &c. from whence there manifestly appears to be a difference in the nature of these acids. Mineral acids have this peculiar to them, that they are excellently adapted to dissolve bodies of the hardest texture, and principally metals but particularly their mercury, wherewith they readily unite; leaving their sulphur untouched. There is no known acid capable of dissolving the sulphur of iron or antimony, which is plentifully lodg'd in them both; but almost any acid that is well prepared, as *Aqua fortis*, *Aqua regia*, spirit of alum, &c. will take up their mercurial part, and with it shoot into crystals. This therefore is peculiar

culiar to mineral acids, that they dissolve metals with regard to their metalline nature, and thence form their vitriols; the whole art of whose preparation depends upon separating the mercurial part of metals from the sulphureous, which is effected by dissolving them in acids. Thus if we would know what metal any sulphureous mineral contains, 'tis but putting it to dissolve in a proper acid, and the metalline part will be thereby separated from the sulphur, and may easily be precipitated out of the menstruum, by presenting another metal thereto, whereon it may act more forcibly than upon the former; which is a method employed to make an acid let fall the metal it had dissolved. Hence gold, which contains but very little sulphur, is perfectly dissolved by them; whilst lead, tin, and the semi-metals, which are largely stocked therewith, are difficultly separated and formed into crystals. Acids in dissolving metals, do not transmute, but divide them into parts of the same nature: Tho we cannot, for want of experiments, say how far they may act upon iron. But since in all solutions the action between the menstruum and the body to be dissolved, is reciprocal; it concerns us to shew how and by what means acids sometimes receive a change in dissolving of metals. Now if a metal has any earthy parts mixed along with it, the menstruum must needs be greatly altered thereby; because acid and earthy bodies exercise an hostility, and mortify one another. Such earthy metals are iron, tin, and lead, whereby the menstruum is blunted and deaden'd. But if the solvend be purely metalline or mercurial, it will scarce work any change in the solvent. Such pure metals as these are gold and mercury, from whence the menstrua may be recovered without any considerable loss of force.

All the acid spirits are reducible to three capital ones; viz. spirit of sea-salt, spirit of sulphur, and spirit of nitre: and these three prove proper solvents for most fossils, but particularly for saline and earthy bodies. But every acid will not work upon every fossil; thus sulphur is not dissolved by spirit of salt nor spirit of nitre. All earthy substances open to acids, as sand, chalk, the testaceous bodies, &c. but the mercurial part of metals is dissolvable only on certain conditions. *Aqua regia*, or spirit of sea-salt, joins it self with gold, copper, antimony, and zink, marcasite, or golden bismuth. *Aqua fortis* works upon all the metals except gold and tin. Spirit of vitriol will not touch gold or silver, lead or tin, but eagerly corrodes, and thoroughly dissolves iron and copper. Whence we see that the action of acid menstrua cannot be determined *a priori*, without particular experiments.

2. *Vegetable acids*, are either native, as the juice of lemons, and almost all summer fruits; or distilled, and that either before or after fermentation, as the acid spirit of box-wood, &c. and of honey, manna, &c. (1.) The native acid juices exert a great solutive force upon all the metals except gold; as also upon various other fossils, as sulphur, antimony, marcasites, &c. Thus if an acid apple be cut with a knife, the blade will be corroded and turned vitriolic by the juice that is left thereon; unless the knife were presently wiped. And thus, as we frequently

quently find, the juice of lemons corrodes and changes the colour of pewter vessels, which vinegar will not do. Nay, these mild and gentle native acids will more kindly work upon, and more thoroughly dissolve, iron, tin, lead and copper, than the strong acid spirits, because of the sulphur, or oil, which such metals contain; which opens the easiest to those weak menstrua. The next in order to these native vegetable juices, obtained by expression, are, (2.) The acid liquors procured from unfermented vegetables by distillation, as particularly from some ponderous woods, as that of box, guaiacum, juniper, &c. which must be cut into chips before they are distilled. These acid liquors dissolve several metals, and other mineral bodies, after a particular manner; and are capable of being rendered exceeding strong. If the distilled spirit of guaiacum be exquisitely freed from its oil, which usually adheres in great plenty thereto, it proves violently acid. (3.) The vegetable acids obtained by means of fermentation, are those of honey, manna, sugar, beer, &c. which turn to a vinegar that yields a very penetrating spirit by distillation. If from a hundred pints of this vinegar, there be first drawn ninety-five of phlegm, all that rises after will be an acid spirit that will dissolve copper into crystals; which being again distilled, afford a very strong and powerful menstruum, that greatly imposed upon *Zwelfer*, who mistook it for the alcahest of *Paracelsus*. These acids dissolve all the metals, except gold, silver, and mercury; but they receive strange changes from some of them, as from iron, lead, and tin; whereby they are mortified, and almost deprived of their force. And if vegetable acids grow sweet upon the body they dissolve, they always suffer some diminution of their strength; as is visible in the case of lead dissolved with vinegar: but when they acquire no sweetness upon the solvend, as happens in their action upon copper, silver, and mercury, they constantly come off sharper and more rigid than when they were put on. The antients talked much of an *Acetum radicatum*; that is, strong vinegar poured back upon its own tartar: and indeed it is an excellent and pretty general solvent.

3. *Animal acids*, I believe, will, if we thoroughly consider the thing, appear to be only notional, and to have no existence in nature; for the acids which are sometimes obtained from milk, chyle, urine or the excrements, and by some called animal acids, do not properly proceed from the parts of the animals themselves, but from what they take in for their nourishment, and have not yet converted and assimilated into their own substance. It has been alledged, that ants, by distillation, afford an acid spirit; tho I could never be so happy as to obtain it, yet I have often distilled them in hopes thereof; but, on the contrary, they always yielded me a fetid alkaline one. 'Tis true, indeed, if the ants be committed to distillation, together with the nests they are found in, something of an acid liquor may be thence procured: this, however, is not owing to the insects, but the leaves and other vegetable substances whereof their nests are composed. In like manner, an acid spirit is obtainable from bees by distillation; but then it proceeds

ceeds not from the animals themselves, but the wax and honey where with they are stored, and which are indisputably vegetable substances. In short, from all the pure insects I have hitherto treated by distillation, I obtained a large quantity of volatile alkaline salt, but never any acid. *M. Homberg*, indeed, declares himself to have extracted an acid from human blood; but that might easily be the sea-salt which is plentifully lodged therein*. We shall now add, by way of corollary to our doctrine of acid menstrums, that *all acid solvents assume a saline form with the bodies they dissolve*. Thus if the solution of coral, made with vinegar, be evaporated to a pellicle, and afterwards set in a cool place, it will shoot into saline, transparent crystals. And the same holds true of metalline solutions, made with acids; from whence are obtained the salts of metals, both artificial, as we see in the salt or crystals of iron, silver, lead, &c. and natural, as in vitriols; which are nothing more than metallic glebes, corroded and dissolved into a saline form by an acid spirit. This also is the case in the solution of stones, effected by acids; as appears by the manner wherein alum is made from chalk: for alum is no more than chalk corroded by an acid, and thereby made to appear in that saline form wherein 'tis found.

The action of
neutral salts.

The action and powers of *adiaphorons* or *neutral salts*, can scarce possibly be known and determined. By neutral salts I mean such as sea-salt, sal-gem, nitre, sal-ammoniac, borax, vitriol, alum, salts artificially compounded, or re-compounded, as the *Tartarum tartarizatum*, *Tartarum vitriolatum*, regenerated salts, and the *Sales volatiles oleosi*. Almost all the bodies in nature are the subjects of their action; yet have they some specific property, whereby they sometimes dissolve particular bodies that other menstrums will not touch. Thus vitriol, sea-salt, and nitre, boiled together in water, make a menstruum that dissolves gold into a red tincture, as we find from *Tachenius* and *J. H. Hollandus*; tho it were in

* *M. Homberg*, one would have thought, proceeded with a deal of caution in the experiment, or analysis, whereby he obtained this disputed acid from human blood, solicitously avoiding the use of any ingredient, or addition, in his distillation, that might be suspected to contain the least proportion of acid. For this purpose he made choice of the *caput mortuum* of human blood it self. The salt thus obtained, he thought justly entitled to the name of acid; because upon particular experiments, purposely made, he found it had all the properties or characters of an acid: and one would think he was too judicious a chemist to be imposed upon in this case by sea-salt; which he could not but know was plentifully lodged in the blood; nay, himself expressly tells us, that he obtained it from all animal substances. But as reasoning, without experiments, ought

never to be trusted in chemistry, whose office it is to make them, we shall drop all argument, and recommend this experiment to be carefully repeated, whereby so material a point may, if possible, at length be settled. It may give great light into the animal œconomy, and the theory of diseases, and direct us to the use of proper remedies to know for certain whether there is or is not contained in the human body any thing deserving the name of a real acid. *M. Vieussens* affirms, *Dr. Piscarn* denies, and *Mr. Boyle*, who seems a neuter in the case, is pressed into the service, and generally charged with roundly asserting that there is no acid at all in the human body. But this matter will be farther cleared up by our author, when he comes to the practical part, or the processes which treat the subjects of the mineral kingdom.

vain to expect such an effect from them in the form of acid spirits. Thus also the *Tartarum tartarizatum*, and *Tartarum vitriolatum*, are admirable menstrua for resolving bodies into a potable form. 'Tis a wonderful experiment of *M. Homberg* and *Ludovicus*, whereby they rendered vitriol and tartar volatile; that by a mixture of native borax, and this by the addition of alum; upon which they both were raised into a salt as white as snow. But who is there that would believe, unless immediately informed by his senses, that the bodies above-mentioned, which prove so fixed in the fire, should ever be volatilized by the addition of borax and alum? The same may be said with regard to metals, which will, every one of them, be raised by sal-ammoniac (whence it has, amongst the chemists, obtained the name of the *white-eagle*) and carried off into the air. When alkalies are thoroughly united with oleaginous or sulphureous spirits (as in *Helmont's effa alba*, which consists of a pure, volatile alkali, taken up by alcohol of wine) there is thereby made a very penetrating and volatile sope, partaking of the nature of the alcahest, which perfectly dissolves all the sulphureous metals, and all manner of sulphurs, oils, and spirits. 'Twould therefore be a great point gained in medicine, if its preparations appeared in the form of a sope, and partook of the nature thereof, like the *Sales volatiles oleosi*, which have some sort of tendency this way. Such preparations would prove admirable menstrua as well as remedies, and dissolve numberless matters; but particularly such as abounded with oil and salt, either in the human body or out of it. Such are the virtues of neutral and compounded salts; for salts may greatly improve their force by composition. Thus, for instance, if to the vinegar of lead a sufficient quantity of an alkali, suppose oil of tartar, be added, to take away its acidity; from hence would arise so mild a menstruum as not to hurt the eyes, or a wounded part, if applied thereto; yet so powerful as to make such a thorough dissolution of myrrh, that its entire body may be taken up by spirit of wine; a thing otherwise very difficult to be done by the most violent means. But for what is said of sea-salt, as to its being an universal menstruum, I could never find reason to expect it should prove so. The result of all the experiments I have, with some pains and diligence, made upon it, is this, that when, by repeated purifications, I had freed it from its bituminous, oily, and fetid alkaline parts, which are largely mixed therewith, from its fishy and other foulnesses given by the sea, and by frequent decrepitations in the fire, and liquefactions in the air, brought it to its utmost degree of perfection, it at length run into a kind of saline oil; but was never so far changed or improved as to dissolve all the bodies whereto I applied it.

All the vegetable menstrua acquired by means of fermentation may be reduced to alcohol of wine. The last effect of all fermenting vegetables is for ever the same; that is, the production of this pure inflammable spirit. I have found, by numerous experiments, made upon dif-

A a a

ferent

Menstrua
gained by
means of fer-
mentation.

ferent kinds of vegetables, that the inflammable spirit they all afford, is perfectly the same; manna, sugar, honey, &c. yield as true alcohol as grapes. This spirit, when perfectly freed of its phlegm, dissolves all aqueous and oleaginous bodies; and all the gummy, resinous, pitchy, and sulphureous ones too; provided they be first opened by alkalies: in which case, as was just now observed, a fine, volatile and penetrating sope would be produced. But upon uniting an inflammable spirituous menstruum with acid spirits, it dulcifies them, or takes off from their sharpness. Thus when spirit of sea-salt is mixed with rectified spirit of wine, it will not dissolve gold, but only extract a yellow tincture therefrom. And spirit of nitre, the solvent of silver, joined with thrice its quantity of the same inflammable spirit, will make no solution, only draw a tincture from that metal much commended for its virtues in the epilepsy.

Now from the several kinds of menstrooms hitherto described, variously united and combined, according to the rules of art, or as accident may happen to direct, there might arise a new and extensive set of solvents, with particular properties and powers: and as the whole mystery of chemical menstrooms had its rise from hence; we may reasonably expect still greater discoveries, from a due improvement of this useful hint.

*Anomalous
menstrooms.*

Besides the menstrooms already treated of, there are others that can neither be reduced to any distinct general kind, nor are capable of being easily imitated by art; which therefore we call *anomalous menstrooms*. Such are the following.

1. *Native, or Venetian turpentine*, which consists of a very exquisite and subtle oil and spirit, which render it so exceeding penetrative and active, that if a scruple-weight be taken upon an empty stomach, and washed down with any proper liquid, it will, in the space of two minutes, communicate its odour to the urine and other excrements. The same property have also the balsams of *Mecha*, *Copaiba* and *Peru*; which are so many species of turpentine. This menstruum will dissolve, or unite with, oils, rosins and resinous gums; and when mixed with sugar, honey, or manna, affords an excellent sope dissolvable in water, where with the turpentine would not before unite.

2. *The yolk of an egg*, which serves as a *Placenta uterina* to the chick, is a surprizing menstruum, tho destitute of taste and smell; being ground with oils, turpentine, or balsams, it renders them dissoluble in water, wherewith some gums, as galbanum, and *assa fetida*, may, by the same means, be united.

3. *The white of an egg* is also a surprizing menstruum; for if it be first boiled hard in the shell, and afterwards suspended in the air by a thread, it will resolve, and drop down into an insipid and scentless liquor, which is that heterogeneous and anomalous menstruum so much used by *Paracelsus*; and will, tho it contains nothing sharp, oleaginous or sapo-

naceous,

nacious, make a thorough solution of myrrh, which is more than water, oils, spirits, or fire it self, can effect.

4. *The gall of animals* is an inimitable sope, consisting of a very subtile animal oil, mixed up with an exceeding volatile salt; whose solutive power manifests it self, by rendering oils dissolvable in water. Physicians are of opinion, that the chyle could not be sufficiently dissolved, diluted, or prepared for its offices without it: and the bitterer it is, the fitter it always proves for such uses.

5. *Honey and Sugar* take to themselves balsams, turpentine, resins, and render them potable or soluble in water. This extraordinary and surprising virtue they have besides, that they dissolve all the gums of *Asia*, as gum-ammoniac, galbanum, sagapenum, bdellium, opopanax, &c. which are scarce manageable by any other menstruums. Sugar, internally used, has the faculty of dissolving, not of increasing phlegm, as is commonly supposed; for it has no tenacity of its own, only acquires it by long boiling. 'Tis the most perfect *sal oleosum*, or unctuous salt, in all nature; being soluble in water, fusible by the fire, and affording all the other signs of a salt.

We are now got thro' the several classes of menstruums, and as we went along endeavoured to shew the virtues and powers of each: but we have hitherto taken no notice of those, in a particular manner pretended to by the adept; who boast themselves masters of some grand secrets in this part of chemistry. Whether there really are such things in being, I will not pretend dogmatically to determine; but leave the authors who speak of them, to answer for themselves. But as *Paracelsus* first made mention of an universal solvent, or the alcahest, and after him *Helmont*, who was a man of uncommon candour, they have together roused the curiosity and industry of abundance of chemists to search after it; for which reason it will not be improper to deliver all we could ever learn of that matter. But before we proceed thereto, let us here draw the consequences that flow from the doctrine hitherto delivered of menstruums.

1. We learn from what is before laid down of menstruums, that a knowledge of the *acid, alkaline, or saline* nature of any body, will not enable us to determine the action of that body upon others, or its power of dissolving them, any farther than particular experiments have shewn to be fact. (1.) Oil of vitriol and *Aqua fortis*, tho the strongest acids, will not dissolve gold, sulphur, or oil. And therefore, when we see spirit of nitre dissolve silver, 'twould be wrong thence to conclude, that it would do so by the other metals. For the fact here is, that spirit of nitre dissolves silver only; and the experiments must be severally made with it to shew whether it will touch the other metals. (2.) The fixed and volatile alkali gained from urine, will not work upon gold, silver, or mercury. *Glauber* sought for the alcahest in alkalies; but never could dissolve the mercurial part of metals with them.

Corollaries from
the preceding
doctrine of men-
struums.

(3.) Tho sea-salt be kept ever so long upon sulphur, or silver, it will not change them.

2. The action, therefore, of all menstrooms is relative; and every body in nature may be accounted a menstruum with regard to the thing it dissolves. Aloes and myrrh will remain untouched in common menstrooms; but if digested with regenerated salt of tartar, and afterwards joined with the saffron, they will all be readily taken up by spirit of wine, and compose *Elixir proprietatis*. But it were a strange way of arguing from hence to infer, that regenerated salt of tartar is the universal menstruum. 'Tis plain, therefore, that the action of every menstruum can only be known, and ought only to be inquired after by experiment.

3. From the dissolving power manifested by a menstruum, we cannot conclude it to be acid, alkaline, spirituous, sulphureous, or saline; for we find by experience, that hard bodies, which obstinately resist the strongest menstrooms, will sometimes yield to the weaker. Mercury thoroughly dissolves the body of gold, tho it self may be applied to the naked nerves without causing pain, or otherwise manifesting it self than by its coldness. Milk will draw a ruby tincture from red coral; which is more than any acid could perform. And alkalies do not always act by absorbing of acids; for they work upon and unite with oils, and bodies that have no acid belonging to them, as flints, for instance, wherewith they compose glass. Whence it is plain, that the action of a menstruum does not let us into its nature.

4. The corrosive power of every menstruum is not absolute and universal, but relative and determinate. Thus oil of vitriol has no corrosive force with regard to gold, wax, glass and the like, upon which it makes no impression; but only with respect to those bodies it is able to dissolve. Corrosion, therefore, is always relative to the body to be corroded; nor can we properly call any body corrosive, before we know the subject it will corrode. Mercury laid upon the warm hand, will give no pain, but feel soft and smooth thereto; yet would it corrode and eat through any metalline vessel, except one of iron. Oil of vitriol, also, and mercury-sublimate, which are ranked among the strongest corrosives, will not work upon silver, crystal of the rock, sand, &c. Hence the antient chemists, who knew nothing of the alcahest, would say that every corrosive is so with regard to its subject, and not with regard to it self. Fire, indeed, is thought to be a general solvent or destroyer, tho we find that it destroys or carries off no body thro' which it can every way pass equably. Thus it does not change and destroy pure mercury, when the force applied thereto is allowed to act no otherwise on one part than on another: but if any particles of arsenic or cobalt, are lodged in the quick-silver, whereby the free motion of the fire is hindered; then the particles of the mercury also are raised along with them; because, in effect, these furnish the other, as it were, with wings.

5. The hardest subjects do not always require what appear to us the strongest and the sharpest menstruums; nor do the softest bodies always yield to those menstruums which work upon the harder: for, as we just now saw, the force of the solvent is relative, and to be estimated only with regard to the solvend. Thus the stone of the bladder, which dissolves in spirit of nitre, will not be touched by oil of vitriol; tho' reputed a stronger acid than the other. Lead opens neither to spirit of nitre, nor oil of vitriol; but readily to the juice of lemons, vinegar, and that spirit also when lowered with twelve times as much water. Coral exposed to the violence of the strongest acids, will communicate no tincture thereto; but immediately yields its redness to white wax or milk. The spirit drawn from rye-bread will melt down stones and metals whilst they are held in the hand, yet never fret or touch the skin; nor give the least pain to the most sensible parts of the body. Whence we may justly hope a solvent will be found for the human *calculus*, that shall not fret or wound the bladder. Steel is the hardest of metals, and will cut them; yet will it be perfectly dissolved by the juice of lemons, or of citrons, which is so grateful and innocent to the tongue. Mr. Boyle tells us he had a menstruum, and gives some hints whereby to discover it, that would dissolve all stones, metals, and even gold, into a soft and potable liquor; the menstruum it self being exceedingly mild and gentle. The reader must again allow me to repeat, that we should not despair of finding innocent solvents for the stones generated in the human body. These stones are found lodged in the urine, gall, blood, lymph, saliva, &c. liquors which will not dissolve them. We likewise know, that saline, alkaline, acid, spirituous, sulphureous, mercurial and saponaceous menstruums, work no effect upon them; but spirit of nitre has the power to do it; tho' it unluckily happens to be a corrosive with regard to the human body. Surprizing cures, however, are daily performed by such menstruums as those above-mentioned, without prejudice to the body. A child chancing to swallow a needle, I ordered him to drink nothing but the juice of lemons, sweeten'd with honey, whereby his stools were rendered black; and he found no farther mischief. To a woman who had contracted a desperate asthma by receiving the fumes of lead, I ordered vinegar; and she was cured.

6. Solvents generally change the solvents, as much as themselves are changed thereby. This made the ancients say, that every solvent was wearied out, or made sluggish, by the solvend in the act of dissolution. Hence action and reaction are equal between the menstruum and the body it dissolves. Thus oil of vitriol suffers so great a change by dissolving iron, that if the solution be distilled, nothing but mere phlegm will come over. Thus fiery alkaline salts are so altered, by dissolving flints and sand, as with them to constitute glass; which is a tasteless body. Pure spirit of wine suffers a less change in solution than any other menstruum: for tho' it should be distilled off from the bodies it dissolves a hundred times, 'twould scarce be diminished in its virtue.

virtue. Yet even this loses of its taste thereby; and the oftner it is distilled, the more insipid it becomes; tho it always remains oleaginous and inflammable. *Zwelfer*, in the trifles he has published about the alcahest, says, there is a certain acid which may be drawn off unaltered after solution. And, indeed, *M. Homberg* informs us, that in a pint of vinegar, for instance, there is a very large portion of earth and water, and but a very small one of acid salt, obtainable in a solid form; which being dissolved in water, makes vinegar again. Such an acid as this, therefore, might suffer no great alteration by being dissolved. Water, tho it does not easily admit of any alteration, is yet by distillation convertible into earth, as *Mr. Boyle* has tried.

7. A great degree of simplicity, purification, or rectification, does not always increase the strength or power of a menstruum, but sometimes proves destructive thereof. Thus common spirit of wine will extract a better tincture from jalap, than that which is highly rectified; and is also to be preferred thereto in making *Harvey's* tincture. Pure oil of tartar will remain distinct in alcohol of wine, but dissolves in a lower spirit, in wine or in water. Oil of vitriol, when highly dephlegmed, will scarce touch iron or lead, before it is let down with water. And *Aqua fortis*, when diluted or exposed to the air, will make a better solution of the calx of lead, than it would when exquisitely purified, or kept therefrom.

8. There are some menstrooms that require the utmost degree of purity before they will operate. Thus amber neither opens to wine, nor the spirit of wine, tho it will to the purest and finest alcohol. It has been asserted, that no tincture could be gained from salt of tartar; but I have, by means of the highest alcohol, obtained a red one therefrom; very different, also, in taste, from that of the spirit employed to extract it.

Of the Alcahest, or Universal Menstruum.

*Introduction to
the history of
the Alcahest.*

P*Aracelsus*, and the elder *Helmont*, have expressly declared in their writings, that there is a certain fluid in nature, capable of reducing all sublunary bodies, as well homogeneous as mixed, into their *Essprimum*, or original matter whereof they are composed; or into an uniform, equable, and potable liquor, that will unite with water and the juices of our bodies, yet retain its seminal virtues; and if mixed with it self again, thereby be converted into pure elementary water: whence they imagined this menstruum could at length reduce all things to water, which, it self, was incapable of any farther change. Such a declaration as this, seconded by the asseveration, or oath of *Helmont*, who religiously swears himself possessed of the secret, caused all the succeeding chemists solicitously to turn their thoughts and labours to find out such a noble menstruum. And the famous *Mr. Boyle* was so fond of it, that he frankly acknowledges he had rather have been master thereof than of the philosophers stone; as indeed it were a thing more to be wished for, than

than the power of transmuting metals: that great philosopher, however, ingenuously tells us he had not the good fortune to possess it.

Now it is easy to conceive, that all bodies might originally grow from some first matter, which was once in a fluid form. Thus the primitive matter of gold is, perhaps, nothing more than a ponderous fluid; which from its own nature, or a strong attraction between its parts, afterwards acquires a solid form. The assertion, therefore, of *Paracelsus* and *Helmont*, carries a shew of probability with it, when they say there is some one universal *Ens*, or original matter, that resolves all bodies into their *Ens genitale*, or the primitive substance whereof they were at first created. So many are the authors who have treated of this subject, that a library might almost be collected of the books written upon the alcahest. *Weiderfelt*, in his treatise *de secretis adeptorum*, has made a collection of all the opinions that have been entertained about it; but 'tis manifest from his writings, that himself never saw the thing. *Pantaleon* also, with *Philalethes*, *Tachenius*, *Ludovicus*, and a thousand others, treat of the same subject. But none of them speak to the purpose, nor declare themselves possessed of the secret, except *Paracelsus* and *Helmont*; who being the original authors, upon whom the rest have only wrote idle comments, or fallen into some whimsical conceit as to this grand solvent, we shall confine our present inquiry to those two; as judging it the readiest way of discovering whatever relates to the subject.

The term *alcahest* is not peculiarly found in any language; and *Helmont* declares he first observed it in *Paracelsus*, as a word that was unknown before the time of that author. *Paracelsus*, in his second book *de viribus membrorum*, Cap. 6. treating of the liver, has these words. *Est etiam Alcahest liquor, magnam hepatis conservandi & confortandi, adeoque ab hydropicis, & ejus omnibus generibus, ab hepatis vitiis ortis, preservandi vim & efficaciam habens. Ejus processus est, ut à coagulatione resolvatur, & iterum coaguletur in formam transmutatam, sicut de coagulando, & transmutando docet. Tunc enim si suum simile superaverit medicina, fit hepatis medicinis omnibus superior. Et siquidem hepar ipsum ruptum & dissolutum foret, loco tamen totius hepatis is est, non secus ac si nunquam ruptum & solutum fuisset. Quicumque ergo medicina operam datis, summo studio id anniti debetis, ut Alcahest præparare discatis, propter aversionem multorum morborum qui ab hepate oriuntur.* The direct and literal *English* whereof, runs thus: "There is also the liquor "*alcahest*, which proves of great power and efficacy in preserving "*and comforting the liver; as also in curing hydropical and all other "*kinds of diseases arising from disorders of that part. Its process is, "*to be dissolved from coagulation, and again coagulated into a transmuted "*form; as is taught in the process of coagulation and transmutation. "*But then if the medicine shall once have conquered its like, it becomes "*superior to all the medicines adapted to the liver: and tho the liver "*it self were broken and dissolved; yet this medicine would supply its "*place, as well as if it never had been so broken and dissolved. "*Whoever, therefore, studies physic, should earnestly endeavour to learn "*the**********

The origin of
the term al-
cahest.

"the preparation of the *alcahest*, that he may know how to put aside the many distempers which arise from the liver." This single passage of *Paracelsus* it must have been which excited the chemists who succeeded him, to such a vigorous inquiry after the *alcahest*: for from a particular perusal of his works, I could discover no more than another indirect expression about it, importing less of the same subject than that just now delivered from him, and one short sentence besides, where he speaks of the *alcahest* as a solvent for some bodies that required calcination, *solvere quadam calcinanda*. It might, therefore, appear surprizing, that *Helmont* should barely from hence take occasion to break out so lavishly in the praises of the *alcahest*, which is not here recommended as an universal menstruum, were we not informed, that in his travels thro' Germany, he picked up all he could learn about it from the disciples of *Paracelsus*. Now we are well assured it was a frequent practice with this author, to transpose the letters of his words, and to make use of abbreviations, or other ways of concealment, in his writings. Thus for *tartar* he would write *stratar*, for *Nitrum*, *Mutrin*; so that *alcahest* may possibly be a word wrote after the same manner: whence some have imagined it to be formed of *Alkali est*; and accordingly, that it was the alkaline salt of tartar volatilized*: But *Helmont* seems expressly to deny it, by saying, "If you cannot obtain to the *alcahest*, learn to make salt of tartar volatile." Others would have it to be the German word *Algeist*, that is, wholly spirituous or volatile: and, indeed, the process mentioned of it, is the same with that of a spirit. There are some too, of opinion, that *Alcahest* is taken from *Salls-geist*, which signifies spirit of salt; for the universal menstruum, 'tis said, is to be wrought from water: and *Paracelsus* himself calls salt, the centre of water, wherein "metals ought to die and lose their bodies." And in effect, spirit of salt was the great menstruum he used on most occasions; as appears from his *Archidoxa*, in the nine former books whereof he reveals all his secrets, except his principal spirituous solvent, or universal menstruum, which in the first he promised to disclose. This occasioned the tenth book to be diligently and solicitously inquired after, wherein a revelation of the grand secret was expected; and at length the bishop of *Cologne* found what passes under that name. The commentator upon *Paracelsus*, who gave a Latin edition of his works at *Delft*, tells us, the *alcahest* was mercury entirely converted and prepared into a spirit. And this is all that ever I could find as to the term *alcahest* in the writings of *Paracelsus* and his translators. But the better to clear up this grand affair, we will, in the next place, inquire if any synonymous words have been used for it.

Paracelsus never speaking expressly of the *alcahest* but in the passage we have quoted from him, has made use of no synonymous term or

Words of the
same import
with the *Al-
cahest*.

* This seems to have been the settled opinion of *Glauber*, who indeed performed surprizing things with such a menstruum, upon subjects of all the three kingdoms.

phrase

phrase for it. Our recourse, therefore, in this inquiry, must be to the elder *Helmont*; who

1. In the *Elziver* edition of his works in *quarto*, given by his son, A.D. 1652. p. 377. n. 3. mentions the *alcabest* by the compound name of *ignis-aqua*, fire-water. But in this place he seems to mean the *circulated liquor* of *Paracelsus*, which he terms *fire* from its property of consuming all things; and *water* on account of its liquid form; and therefore by joining the two words together expresses both its properties at once.

2. Pag. 45. n. 15. and pag. 119. n. 89. he calls it *Ignem Gehemæ*, infernal fire; a word also made use of by *Paracelsus*. In the place first cited *Helmont* is treating of original, that is, elementary earth, "Which," says he, when perfectly purified and freed from all foreign matter, "can be changed by no body in nature except the infernal fire, which will reduce it into the same fluid whereof it was originally composed." Whence it is plain, that this *infernal fire* was an artificial thing; and the same with the *alcabest*.

3. Pag. 628. n. 2. he calls it *Aquam solventem*, a dissolving water; and here says, "There is another synonymous word for it in *Paracelsus*, namely *sal circulatum*, which reduces all tangible bodies into the liquors they were made from."

4. Pag. 380. n. 24. he entitles it *Summum & felicissimum omnium salium*; the principal and most successful among salts, which having obtained the highest degree of simplicity, purity, and subtilty, alone enjoys the faculty of remaining unchanged and unimpaired by the subjects it works on, and of dissolving the most stubborn and intractible bodies, as stones, gems, glass, earth, sulphur, metals, &c. into real salt, equal in weight to the matter dissolved; and this with as much ease as hot water melts down snow. This salt, also, continues he, by being several times cohobated with *Paracelsus's sal circulatum*, loses all its fixedness; and at length becomes an insipid water, equal in quantity to the salt it was made from." Now *Helmont* has given a very accurate description of salt, and consequently could not but know what it was; so that we cannot well mistake him when he calls the *alcabest* a salt.

5. Pag. 43. n. 11. and pag. 157. n. 6. he gives it the name of *Sal circulatum Paracelsi*, because made by a circle of distillations and cohobations; and says he had two kinds thereof, a less and a greater, which latter is that of *Paracelsus*, and esteemed by *Helmont* the same with the *alcabest*.

6. Pag. 94. n. 27, 28. he delivers, tho' very obscurely, the whole composition of the *alcabest*, with all its virtues; where he calls it *latex*, which properly signifies pure, transparent, running water. *Helmont*, therefore, being a thorough master of the *Latin* tongue, must mean by that word, as here applied, *transparent salt reduced to a fluor*. The passage being very remarkable, we shall give it in the original. *Chemia indagando sollicita est corpori, quod tantæ puritatis symphonia colluderet nobiscum, ac à corrumpente nequiret dissipari; ac tandem stupefacta est religio, reperto latice,*

lattice, *qui ad minimos redactus atomos naturæ possibiles, cælebs omnis fermenti connubia sperneret.* Which words may be thus rendered: "Chemistry busies her self to find out a body so pure, to make harmony with us, as that it self should remain incapable of corruption or dissolution; and at length religion stood amazed at the discovery of a pure, limpid, running water, which, tho reduced to the smallest particles in nature, keeps it self unviolated; refusing the embraces of every ferment." By religion the author here understands the chemical religion, or the doctrine and practice of chemists.

7. Pag. 88. n. 27. he gives it the title of *water*; where he thus expresses himself: "I know a certain *water*, which I cannot think proper to reveal, wherein all manner of vegetables are changed into an exhalable juice, without the least sediment falling to the bottom of the containing glass: and this juice, when applied to salts, is wholly reducible into insipid and elementary water." He also quotes the first chapter of the second book of the *Maccabees*, where mention is made of a water that took fire, to this effect: "Now when the sacrifice was burnt, *Nehemiah* commanded the great stones to be sprinkled with the residue of the water; which, when it was done, there was kindled a flame of them also; but it was consumed thorough the light that shone from the altar. So when this matter was known, it was told the king of *Persia*, that in the place where the priests which were led away, had hid fire, there appeared water instead of fire, and that *Nehemiah* and his company had purified the sacrifices withal." And to this liquor he compares his alcahest, telling us it was thick, a perpetual fire like the vestal, and not unlike what is describ'd in the chapter of the *Maccabees* already referred to. So much for the synonymous terms which have been used for the alcahest; but if we would know what our two grand chemists meant by their universal menstruum, we must not rest our inquiry in the etymology and phraseology of the word, but search into the origin, properties, and characters of the thing; and, by comparing together the obscure passages of both writers concerning it, see if we cannot make one explain the other; so as to let us a little into this grand secret.

The origin of
the alcahest.

1. *Helmont* expresses that this menstruum is entirely the product of art, and not of nature; as appears from pag. 56. n. 12. of his works; where he says, "Tho an homogeneous part of elementary earth may be artificially converted into water, yet I deny that the same can be done by nature alone; for no natural agent is able to transmute one element into another." And this he offers as a reason why the elements always remain the same in quantity. *Helmont*, as well as *Paracelsus*, took water for the universal instrument of chemistry and natural philosophy, and earth for the unchangeable basis of all things, which, according to him, was created by God to give form to bodies; that fire was designed as the efficient cause of all things; that seminal impressions were lodged in the mechanism of earth; and that water, by dissolving

dissolving and fermenting with this earth, as it does by means of fire, brings every thing to light; whence originally proceeded the animal, vegetable, and mineral kingdoms; even man himself being thus at first created, agreeably to the account of *Moses*. Nor does there appear any absurdity in all this. Earth, therefore, according to him, was naturally indestructible; yet convertible into water by the action of the alcahest, which, therefore, is not a natural body, but an artificial preparation.

2. *Pag. 94. n. 28.* he declares the alcahest to be unobtainable without the *labor sophia*, the work of wisdom, or secret knowledge of the adept, whereby they prepare the philosopher's stone; which he tells us is incomparably more easy to procure than the alcahest: and of the great difficulty and labour requisite in its preparation, he expresses himself to this effect: "No body ever yet made a cure of the leprosy without the assistance of the *alcahest*, which cannot be obtained without a tedious and laborious operation: and however great the skill of the artist may be, and whatever pains he may take, yet shall he never possess this menstruum but by a particular favour of providence. Great is the *labor sophia*, the work that has made a breach into nature, and shewed us an anomalous preparation, that without mixing with any ferment, rises a serpent different from it self, dies by its own bite, but revives again, and yields to death no more. The *ludus* of *Paracelsus* may be made in a moment, but the difficulty is to prepare the *alcahest*; than which nothing in all the art of chemistry is more laborious." And thus much may serve to shew the errors of those chemists, who, since *Helmont*, have severally pretended to the *alcahest*. *Ludovicus*, *Starkey*, *Zwelfer*, *Glauber*, &c. thought themselves possessed of it, without taking the pains that *Helmont* declares to be necessary in its preparation. *Basil Valentine* and *Zwelfer* judged it to be spirit of vinegar rectified from verdigrease; *Starkey* thought he discovered it in his sope; and others would make us believe they found it in fixed alkalies, or acquired it at some very easy rate. But so far were such people from having had the secret of the alcahest, that they knew not how to go about its preparation; and wanted a true notion of the thing. Whoever expects to obtain it in good earnest, may take *Helmont's* word for it, he must not only bestow uncommon pains, but also prove very happy if he obtains his end. And tho we were persuaded a man knew the secret of the philosophers stone, we should still be cautious how we believed him possessed of the alcahest.

Let us next inquire into the distinguishing marks and characters of the universal menstruum. The properties
of the alcahest.

1. Its first character, or property, is to dissolve and change all sublimary bodies; water alone excepted.

2. The changes it brings upon them proceed in this order. Every subject exposed to its operation, is first converted into its three principles, salt, sulphur, and mercury, and afterwards into salt alone; which then becomes volatile, and is at length wholly turned into insipid water.

B b b 2

3. But

3. But this operation proceeds not equally in all bodies; metals, and above all, that particular sand which lies where the purest springs take their rise, below the earth, being dissolved by it with greater difficulty than other bodies. If any one, therefore, pretends to the alcahest, bid him first dissolve this sand with his menstruum, before you assent to his assertions about it.

4. The manner of making the experiment, is to touch the body proposed to be dissolved, once or twice with the pretended alcahest, whilst the subject is contained in a proper vessel; and if the liquor be genuine, the body will thereby be converted into its own quantity of salt. Thus if it were applied to an ounce of sand, gold, or mercury, you would obtain by the experiment an ounce of the salt of each body, without any mixture of the menstruum, or change being wrought thereon. See *Helmont's* works, p. 88. n. 24—28. p. 265. n. 11.

5. It does not destroy the *seminal virtues* of the bodies dissolved thereby. Thus gold is, by its action, reduced to a salt of gold, antimony to a salt of antimony, saffron to a salt of saffron, &c. of the same *seminal virtues*, or characters with the original concrete. By *seminal virtues* *Helmont* understands those virtues which depend upon the construction or mechanism of a body, and which make it what it is. Thus if a pound of cinnamon were, by the alcahest, reduced to a pound of salt, this salt would retain the smell and taste of cinnamon; tho it would now become soluble in water, and would run by the fire. Hence an actual and genuine *Aurum potabile* might readily be gained by the alcahest, as converting the whole body of gold into a salt retaining its seminal virtues, and being soluble in water. See *Helmont*, p. 25. 43. 88.

6. Whatever it dissolves may be rendered volatile by a sand-heat, or the heat of a *Balneum Mariae*, as we learn from a very remarkable passage of our author, p. 88. which take in the following words. "I put a charcoal of oak into a glass vessel, with an equal quantity of a certain water, and sealed the glass hermetically; whereby, in three days time, the entire coal was, with the heat of a bath, converted into two transparent liquors, of different colours; which being distilled off in a sand-furnace, with a fire of the second degree, the bottom of the glass appeared as pure and clean as if it had just been taken out of the glass-house kiln. These two liquors afterwards rose by the warmth of a *Balneum*, equal in weight to the matter of the coal; whilst the liquor which had procured the dissolution, remained at the bottom of the glass, without having lost of its weight or virtue." If any one, therefore, pretends to the alcahest, let him do the like, or pass for a deceiver. The universal menstruum, he tells us, may also fix some bodies, as mercury for instance, so that they shall not easily recover their volatility. See *Helmont*, p. 380. n. 24. p. 776. n. 11. p. 628.

7. If, after having once volatilized the solvend, it be distilled therefrom, the body is left pure insipid water, equal in quantity to its original self, but deprived of its seminal virtues. And this must be the case of all

all the bodies in nature. Thus if gold be dissolved by the alcahest, the metal first becomes salt, which is potable gold; but when the menstruum is distilled therefrom, 'tis left mere elementary water. Whence it appears, that pure water is the last production or effect of the alcahest. See *Helmont*, p. 43. 56. 780. n. 25.

8. It suffers no change or diminution of force by dissolving the bodies it works on; and therefore sustains no reaction from them; being the only immutable menstruum in nature. Our author calls it, "A virgin that refuses the embraces of every ferment, because it can find nothing like it self wherewith to unite; and the principal of salts that has the power of pervading all bodies, whilst it self remains unchanged thereby." Hence he calls it, "*Liquorem aeternum*, the immortal liquor; which, *says he*, has no equal; for as there is in all nature but one burning and consuming fire; so is there but one liquor capable of dissolving all bodies into their primitive matter, without receiving the least change or diminution of its virtues." See *Helmont*, p. 45. n. 15. p. 94. n. 27, 28. p. 678. n. 12. p. 628. 265. n. 11. p. 628. 678. p. 780. 788.

9. 'Tis incapable of mixture, and therefore remains free from fermentation and putrefaction; coming off as pure from the body it has dissolved, as when first put thereon; without leaving the least foulness behind it: for it acts no otherwise than a pestle does in a mortar, by grinding to pieces the bodies whereto it is applied, it self remaining unaffected or unchanged by the action. See *Helm.* p. 94, &c.

10. 'Tis exhalable, or may be raised, by a sand-heat, but not by the heat of a *Balneum*, as we learn from the distillation of the wood-coal, dissolved by means of it; which strange property seems repugnant to some of those above-mentioned. See *Helm.* p. 56. 88. 628. 634. 766, &c.

11. Lastly, notwithstanding what was said of its immutability, 'tis not absolutely incapable of change; but may be altered and subdued by its equal: and such an equal our author declares it has, tho he never describes it; which, therefore, must be a body that eludes the force of the alcahest, changes its nature, and destroys its virtues. See *Helm.* p. 265. n. 11.

The properties here delivered of the alcahest, are extracted from the writings of the elder *Helmont*; but neither those, nor all the information to be gained from the younger, will enable us to form any solid and satisfactory judgment about this surprizing menstruum. The son being frequently questioned by his friends concerning the immortal liquor of his father, always studied to return evasive answers; and left them in the dark as to the truth of the thing. But when he was once, at my request, entreated to say whether his father actually possessed such a menstruum or no, he acknowledged he knew not; but said that his father often boasted of more than he could perform. These properties of the *alcahest*, may furnish us with a criterion whereby to examine the pretensions of those who would be thought to have got possession of

of the secret. If any man pretends to an *alcahest* of a different kind from that we have here described, it lies upon him to shew how he applies the term, and what are the effects and properties of his particular preparation; but whoever would persuade the judicious that he has obtained the *alcahest* of *Paracelsus* or *Helmont*, must shew that it bears the several marks and characteristics peculiar to that liquor: and if it appears to have the several properties above laid down, you may fairly conclude it to be the genuine *alcahest* of *Helmont*.

Many are they who have pretended to this extraordinary menstruum. *Starkey*, that excellent chemist, disciple to *Helmont*, and friend of *Mr. Boyle*, was, as well as some others, of opinion, that it might be a preparation from putrefied urine. Hereto they were led by those passages of *Helmont's* works wherein he expresses himself to this effect: "Wisdom despises those who are averse to work upon putrefied urine." And speaking of the *ludus*, that is, the human *calculus*, he says, "Putrefied urine will dissolve the stone." But he could not mean by these or the like expressions, that putrefied urine was really the *alcahest*; because urine, in what manner soever it be treated, always has something sulphureous or saline mixed therewith; and consequently would give a foulness to the bodies it dissolved, and be altered by them; which is directly opposite to the nature of the *alcahest*. And spirit of urine, being an alkali, is for that reason expressly declared by *Helmont* not to be the thing. All the other preparations from urine would likewise suffer a change. The oil of urine may be transmuted, and the *ossa alba Helmontiana* is alterable by acids; characters no way comporting with the *alcahest*. The like we must also say of *phosphorus*; which has therefore been taken for the *alcahest*, because *Helmont* describes that universal solvent as a thick, shining, fire-water; but this will unite with *Aqua fortis*, fly off, and lose its virtue in the air, flame and be entirely consumed by the fire, mix with oils, and not fix mercury. Others will have it to be a preparation from salt of tartar; but *Helmont* is express to the contrary, as appears by the following words: "Whoever it is that practises the art of physic, and has a concern for his neighbour's welfare, let him learn to prepare such a solvent as is homogeneous, unchangeable, and able to reduce all its objects to their original liquid matter, whereby he will obtain the very internal essences of things, and see their qualities and dispositions; but such as cannot attain to this secret, ought, at least, to learn how they may render salt of tartar volatile; by means whereof they may make uncommon dissolutions." *Helm. p. 43. 56. p. 78. n. 25.* This salt also will receive a change both from acids and oils.

The author's
opinion with
relation to it.

If I may be allowed to speak my opinion in this affair, I cannot believe the *alcahest* was ever obtained from vegetable or animal substances; but, if at all, either from salt or mercury. Salt appears to have afforded *Paracelsus* an universal menstruum; and in the tenth book of his *Archidoxa*, published by the bishop of *Cologne*, cap. 14. where he treats
of

of the preparation of magisteries; we find words to this effect: "In our other writings we have sufficiently shewn that the sea, or water is the great element of nature; being the seed of all things, and the true mother of metals; which is what no body had observed before us; all other authors deriving their origin from sulphur, mercury, &c." *Helmont* also agreed with him in opinion, that water was the mother of all metals. But then they tell us, that this sea-water has a quintessence, which is its salt, which when reduced to its highest possible degree of purity and simplicity, seems to be that first menstruum of *Paracelsus*, which turns mercury into water. The method of making this menstruum, *Helmont* thus describes: "Take two parts of the element of water, or sea-salt, which has never felt the fire, mix it with one part of horse-radish water, and purify them together, for a philosophical month, and the salt will thereby be converted into a kind of oil, supposed to be the *sal circulatum* of *Paracelsus*, and an universal solvent, which may properly enough be called a spirit of salt." But this does not appear to be the greater *sal circulatum* of that author: for it will not produce the effects ascribed thereto. I have myself made the experiment, and find the digestion of the salt will succeed, if treated after the manner directed in the process. That *Paracelsus*'s second menstruum, or grand universal solvent, was also a spirit of salt, seems countenanced by *Helmont*, who in his fourth chapter *de primo Ente*, bids us "dissolve mercury in the sea, that is, in sea-salt, and putrefy, that is, digest, it when dissolved, till anomalous fæces fall therefrom." *Paracelsus* farther says, "that mercury is an element generated from sea-salt, which it self is composed of water; that all metals and minerals are made from mercury; that every body ought to be dissolved in its own menstruum, and first to be killed by that wherein there is life; that all things may be composed of water, and meliorated thereby, whence at length it self may be converted into the universal medicine, or the philosophers stone." *Archidox. Lib. 10.* And *Helmont* places the principle of indestructibility in the nucleus of mercury. The process for the second *sal circulatum* of *Paracelsus* begins thus: "Run sea-salt often in the air, and dry it again, afterwards digest it with horse-radish, distil and reverberate it in a retort, then dissolve it in more sea-salt, digest it again with horse-radish, distil and repeat the several parts of the operation till the whole matter becomes a coherent mass, and all the fixed salt remains at the bottom; then sublime, &c." See *Paracels. Archidox. lib. 10.* This operation is exceeding tedious, laborious, and intricate. I have in the space of two years made above a hundred experiments in order to obtain the menstruum it promises; but when, at length, I thought my self almost possessed of it, I could go no farther than to the subliming part; for I never found out what it was to sublime a pure fixed salt in sea-salt. We see then that *Paracelsus* seems to have had two kinds of principal menstrooms, a saline one, or sea-salt rendered exceeding pure and subtile,

Theory of CHEMISTRY.

and another that was metalline, consisting of mercury converted by the former into a mercurial water; which proving capable of dissolving all things, might possibly be the *alcahest*. And this is all I could ever gather from the writings of *Paracelsus* and *Helmont*, with relation to the universal menstruum; which, from their times, has employed the studies and labours of so many famous chemists, with great expences, to discover.

Having gone thorough the subject of menstrooms, and explained every other part of our definition at first laid down, except what relates to instruments properly so called, we come now to the consideration of these. Chemistry we said was an art that by means of certain instruments changed sensible bodies, capable of being contained in vessels, so that the alterations they underwent might become visible. Whence all these changes are to be made in vessels, by means of certain instruments, which, therefore, 'tis in the last place, our business to describe.

Of INSTRUMENTS, properly so called.

Chemical instruments, what.

ALL the parts of the *materia chemica*, whilst under examination, must be contained in proper vessels, to keep the matter from running into, or mixing with the fire, or fuel, employed; and these vessels ought so to restrain, moderate and determine the heat upon the bodies exposed thereto, that the operations may receive no hindrance: which end can only be obtained by means of proper chemical instruments. Proper chemical instruments, therefore, are the bodies by means whereof the moving cause, or fire, is applied and determined to the subjects proposed to be changed, in a manner capable of effecting that change. Such instruments are chemical vessels and furnaces.

CHEMICAL VESSELS.

Chemical vessels, what.

CHEMICAL vessels are hollow bodies fitted to contain the subjects to be changed, as well during the time of their change, as before and after it is effected. These vessels differ from one another in respect of their matter and figure; and are made of three different bodies, metal, earth, and glass.

The metalline.

Metalline vessels have two inconveniences; being apt to foul or change the nature of the subject, as particularly of acids, which will corrode them; and fusing with a violent heat, which would soon have this effect where tin and lead are concerned. But when neither of these inconveniences is to be feared, metalline vessels are the most useful; and will suffer nothing to transude thro' their pores. They are generally preferable when they can be defended from the coldness of the air, which might happen to crack or split them; for they will endure a great violence of fire without being destroyed thereby; especially if made of iron that has been once fluxed; which will cause it to sustain twice

twice the heat it otherwise would do; tho even this stout metal will at length begin to vitrify.

Vessels of earth, provided they will neither flow nor vitrify in the fire, are admirable. Of this matter, or the powder of earthen-pots, are made crucibles, and Hassian retorts, which may be used in those operations that require the greatest violence of fire; tho they will be melted down by a burning concave. They are likewise subject to waste alkalies, to be corroded by acids, to be calcined by the fire, and to let spirits escape thro' their pores in distillation; for which reasons, they are only proper to be employed in the fusion of metals. Of all other earthen vessels, those of porcelain appear the most excellent; because they suffer no alteration from what they contain; tho even these melt and crack with heat; but especially if they are glazed. Vessels of chalk also may have their use; but these are dissolvable by acids, unless kept in a very strong fire. This kind of vessels are employed by those persons at Amsterdam who distil very large quantities of spirit of nitre, oil of vitriol, Aqua fortis, &c. But if they be, for ever so little a while, exposed to the cold air, with acids in them, they presently crack or fall to pices.

Glass-vessels share many advantages: they do not defile or mix with the bodies they contain; nothing hitherto appearing to dissolve them but strong spirit of salt; not even mercury, the strongest acids and alkalies, or the sulphur of arsenic. These also are impervious to strong spirits, as Aqua fortis, spirit of nitre, and other acids, which could not be contained in metalline vessels. *Helmont* declares, that even his *alcahest* might be exposed to the fire in a glass-vessel. But the matter whereof these vessels are made, should not be the white, crystalline glass, which is apt to crack, and soon flows in the fire, by reason of the large proportion of fixed alkali contained therein; which also gives an urinous taste to some bodies. The green glass is the strongest, most durable, and fittest for chemical uses; as containing the greatest quantity of earth. This advantage is peculiar to glass-vessels, that being transparent, we may, by means thereof, view the subject during the time of an operation, and observe, thro' their sides, the several changes made by every step of the process. Their greatest imperfection is, that they cannot endure a higher than the third degree of fire, without growing soft, and melting; and can, therefore, never serve in the fusion of any metals, unless of lead or tin. But in any degree of heat below the third, we may very commodiously make use of glass-vessels; since, of themselves, they neither bring any change upon the objects, nor suffer them to transude, or escape.

The figure of vessels differs with the uses for which they are designed. Chemists, in all their operations, have occasion for no more than two kinds of vessels, viz. containing and receiving. They require only a vessel that shall contain the body they design to change; and another to receive it after it is changed. Now the vessel containing the matter to

See Fig. 10 and
II.
Plate 1.

be changed, must either be exposed to a close or an open fire: in the latter case, only single vessels, such as pans or dishes, melting-pots, crucibles, tests, &c. are employed. But when things are committed to a close fire, numberless different vessels may be used; tho' all of them are reducible to two kinds, *viz.* the *cylindrical* and the *conical*. Vessels of a true cylindrical form are very rarely employed in chemical operations. *Cucurbits* come the nearest to it, which are frequently made choice of where a distillation is designed to be uniformly carried on. Conical vessels are of two kinds; the figure of the cone being erect in some, and in others inverted. The former rise taper from a broad circular base; whereby the sides approach one another the nearest at the top. These we make use of when we design to hinder the ascent of the bodies exposed to the heat: for the inclination of the sides of the vessel will here prove an obstacle to the rise and escape of the fumes, which might otherwise fly off. The latter, or inverted conical vessels, rise broad from a narrow circular basis, and open in a wide mouth at last. And these are employed, with a view, contrary to the former, to separate and obtain the more fixed parts of bodies from those which are lighter and more volatile: because the sides of these vessels obstruct not the rise and avolation of the more fugitive matters submitted to the action of the fire. A true knowledge of the nature, uses, and application of all the chemical vessels depends upon rightly conceiving the reason of their different structure. If a vessel were perfectly cylindrical, it appears from geometry and hydraulics, that the fire, acting in straight lines upon any substance lying at the bottom thereof, would give it a motion directly upwards; and that this motion would not be resisted or altered by the sides of the vessel. But should these sides converge towards the mouth, and so give a conical form to the vessel, much of the matter that was raised by the fire would impinge, or strike against them, and thereby be obstructed in its elevation; for no more parts would now be carried off than what never struck against the sides, or could overcome the resistance they make to the force wherewith such parts tend upwards. If, therefore, the mouth of the vessel were infinitely small, no particle could escape thereat; and all those that rose would then fall back again; on the other hand, if the vessel had no sides at all, but was entirely flat, or every way perfectly open, it self would not in the least obstruct the rise and escape of the volatile parts. Hence we see the reason why cupels are made flat, with little or no sides belonging to them; and why distillation is the easier performed in such vessels as are both low and wide. Distillation, as commonly conceived, is the ascent of certain moist particles in the form of a vapour; and consequently must proceed in proportion to the height, and the obstacles that might any way retard it: it will therefore always be in a ratio compounded of the direct proportion of the orifices of the containing vessels, and the reciprocal of their altitudes. Thus if the same matter were, with the same heat, to be distilled in two cucurbits of equal heights, but

of different diameters at their mouths, the quantity of liquor gained by the operation would be as those diameters. Those bodies, therefore, which are distilled with difficulty, should be committed to a broad and low vessel; and such as are very volatile, to a narrow and a tall one. Thus by nicely adjusting and suiting your vessels, rectified spirit of wine might be brought to boil below, whilst no particle should rise so high as to escape into the air; or mercury be agitated with a violent fire without suffering any loss, &c. And by this means it is, that some uncommon and extraordinary things have been performed in chemistry.

The principal vessels requisite in the practice of our art, and such as we shall hereafter have occasion for, are those which follow.

1. A *cucurbit*, which is a bellied vessel, broad at bottom, but narrower upwards, called in the Dutch language by the same name with *Hercules's club*, from the resemblance it bears thereto; but the Latin *cucurbita* originally signifies a gourd, whose figure is not ill represented by our vessel; which, however, sometimes differs from it self; for it may have a neck of equal diameter with the bottom, or slenderer or wider than that. This vessel, therefore, is fit for those distillations wherein the vapour is designed to rise high. Cucurbit.
Plate I.
Fig. 1.

2. A *matras*, otherwise called a *bolt-head*, or *egg-vial*, is a vessel of a capacious, roundish or cylindrical bottom, joined to a slender neck, and consequently a species of the *cucurbit*; having only a narrower mouth and a longer neck than that. If the neck of one *matras* be inverted into that of another, the two together make what is called a *circulatory vessel*. And that instrument, or vessel, which is placed upon the *cucurbit* or *matras*, to keep in or condense the vapour in distillation, is termed a *head*; as in the alembic, which we shall see presently. The *matras* is of use when no separation is intended to be made, by the rise of vapours thro' the neck, as in extracting tinctures, &c. Matras.
Fig. 2.

3. A *retort* is a bellied vessel, with a bent or angular, and slender neck; being an artificial compendium or improvement of the two former; for it answers all the purposes of those, without the assistance of a head; which they sometimes require: and distillation may, by means of it, be performed in a simple manner; this requiring nothing to fit it for that purpose besides a receiver. Retort.
Fig. 3.

4. A *receiver* is the vessel employed to arrest and contain the body submitted to a chemical process or operation, after it is changed by the fire. This vessel may be any convenient thing, and is usually no other than a *matras*, whose mouth admits, and receives the bent neck of the retort, thro' which the changed matter flows into the belly of the receiver. Receiver.
Fig. 4.

We may now understand the contrivance and nature of that manner of distillation, whereby strong, acid, or saline spirits are obtained. This is performed by a set of perforated vessels, or long-necks, exactly joined and fitted one into the neck of another; and serving as one long continued retort, that ends at last in a receiver: by which means the journey of

the vapours being lengthened, they are cooled in the passage, tho they never rise high. Were it not for this contrivance, which gains length to the retort without adding to its height, and may be continued out to any distance we please, strong acid spirits could never be obtained with any tolerable profit or safety; for not being able to rise high enough in distillation to cool themselves, they would break the receiver to pieces by coming hot into it; and hence great damage has been sustained: but by placing the compound retort horizontal, oil of vitriol, *Aqua fortis*, &c. are readily distilled to advantage.

Alembic.

Fig. 5.

Fig. 6 and 7.

Fig. 8.

Fig. 9.

5. An *alembic* is an instrument of this nature; being no more than a matras fitted with a roundish head, perforated in a sloping stem, or tube for the condensed vapours to pass through, which they do in the form of a liquor, into the receiver. This instrument was known to *Dioscorides*, who says, that cinnabar may be raised *ex aqua*; whence comes the word *alembic*, by prefixing the *Arabic al* thereto. And hence is readily understood the structure and use of the copper alembic, as well as of the cold-still, which nearly resembles the glass-alembic; its head being made of pewter, and its bottom of copper, but lower and wider than the matras.

6. A *pelican* is a short and easy combination of all the just-mentioned vessels and instruments; being a *cucurbit* joined to a fixed, blind-head, in the nature of an alembic, which again communicates with the body by two hollow handles rising out of the opposite sides; whereby distillation and cohobation are both carried on at the same time; the liquor that ascended in vapour being condensed by the head, and afterwards returned upon the matter below, without opening the vessel, which has only one orifice at top to receive the subjects of the operation. This contrivance is greatly esteemed and applauded by the chemists, and has been much used by the adept in the preparation of their stone; but it comes dear, and has this inconvenience besides, that if it be not every where exactly closed, all the matter it ought to include, escapes; and yet if it be firmly shut up, it is apt to break by too great a heat; whilst a small one will not prove sufficient to raise the matter. For this reason I rarely make use of a *pelican*; but in its stead chuse two *matrasses*, with very long, slender necks, and invert the mouth of one into that of the other, and in the lower put the matter I would distil or circulate. This compound vessel, or circulating-glass, I place in a furnace fit for the purpose, and lute the juncture, having first well heated the glasses to rarify and exclude the air contained within them. After this, I suffer the matter to boil, without any danger of breaking the glasses, which would now happen if they were thus joined together in the cold. Thus, for example, if I would reduce mercury to a red powder, I put a pound thereof into an egg-vial, with a long stem, and invert another therein; then exposing them to a proper heat, that both the glasses may grow warm, I close the juncture, and commit it to the fire; which will now drive up the mercury to the top of the lower matras, and let

PLATE. I.

CHEMICAL VESSELS.

To face p: 376

CVCVRBIT.

MATRAS OR BOLT-HEAD.

Fig. I.
Pag. 375.



Fig. II.
Pag. 375.



Fig. III.
Pag. 375.



RETORT.

RECEIVER.

ALEMBIC.

Fig. IV.
Pag. 375.



Fig. V.
Pag. 376.



Fig. VI.
Pag. 376.
379.

COLD-STILL.

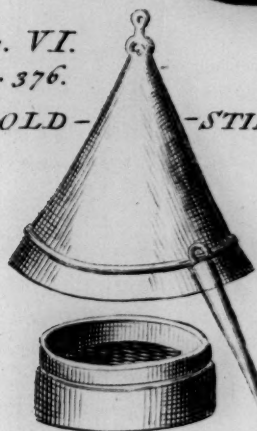
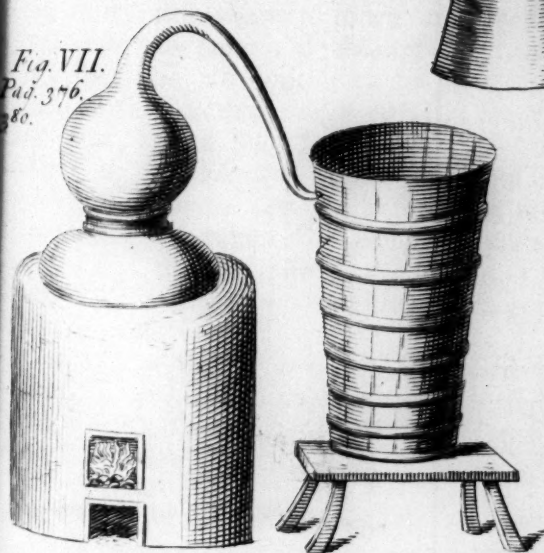


Fig. VII.
Pag. 376.
380.



COPPER ALEMBIC
WITH ITS REFRIGERATORY.

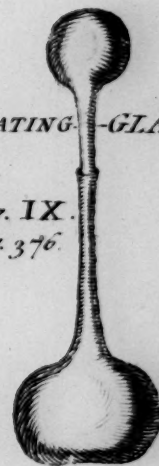
Fig. VIII.

PELICAN.
Pag. 376.



Fig. IX.
Pag. 376.

CIRCULATING-GLASS.



CRVCIBLE.

Fig. X.
Pag. 377.



TEST.

Fig. XI.
Pag. 377.



it fall back again, till the work is finished. This vessel was known above a thousand years ago; and had the name of *pelican* given it from its action, which resembles that reported of the bird famous for nourishing its young with its own blood.

The nature of the bodies to be worked on, their degree of volatility and fixedness, and the parts designed to be obtained therefrom, or the union and mixture to be made thereof, will direct to the proper choice, application, and position of the several vessels we have here described. The more volatile the matter to be distilled, or the more open and subtile the body from whence any thing is to be drawn, the higher should the receiver be placed, and the narrower its neck, and that of the cucurbit or matras. Thus, for example, if you would separate pure spirit of wine from the water wherewith it may happen to be mixed, make choice of a very tall vessel; and, with a proper degree of fire, nothing but the spirit will ascend into the receiver. But where the subject to be distilled off, is less volatile and subtile than that spirit, the vessel should neither be so tall, nor so narrow at the top *.

Their manner of use.

Of FURNACES.

Furnaces are those instruments, or machines, employed in the practice of chemistry, whereby the fire requisite to the operations of that art, is kept together, moderated, and determined upon the subject to be changed. Every furnace, therefore, must be capable of containing fire, of restraining or keeping it from spending it self too fast, and of guiding and directing it, as the end whereto it was designed shall require. Hence we learn that furnaces have a double office to perform, as regarding not only the fire, but also the subject to be changed thereby. With respect to the former, they must have a current for the air, a chimney, a fire-place or grate, and a hole for the ashes; and with regard to the latter, a place for the chemical vessels to stand in.

Furnaces designed.

Those furnaces are the best which are most simple and easy in their construction, produce the effects required from them with the least expence and trouble, afford a constant and equable degree of heat, and allow their fire to be recruited, managed, and directed with all desirable convenience.

Which the best.

A furnace should perform its office with little expence; that is, it should entirely consume the fuel designed to feed the fire, and let the whole force thereof be spent upon the subject to be changed; without any part being lost, or suffered to go aside. It should afford a constant

* To these might be added numberless other kinds of vessels, differently contrived to answer the same or different ends; but since a course of chemistry may very well be carried on with these few simple ones, and the assistance of *tests* and *crucibles*, it is needless

here to describe any more: the commodious preparation of vendible commodities in large quantities, and to the greatest profit; being foreign considerations, regarding the trade of chemistry rather than the art.

degree of heat, that the fuel may have its effect without loss of time, and not at every turn require the presence and assistance of the artist. The heat should also be equable, because every degree of fire has different effects upon the same subject. So that when a chemist is requested to change a given body into one of another species, with an assigned degree of fire, if he should happen to vary that degree, he would never obtain the production required. This ought to be heeded, fully attended to in chemical operations; for if the fire should once be lowered when it ought to have been raised, or kept up to the same degree, 'tis in vain to expect a perfect production from the operation; how much soever you afterwards increase, or carefully regulate the fire.

The perfection, therefore, of furnaces consists in being easily made, and of cheap materials, so as to suffer the fire to act equably on the subject in any assigned direction and degree; which will depend upon the quantity of fuel made use of, its nature, and the current of the air thro' the same. The fire that is every way enclosed and guarded from the air, or every way equally exposed thereto, will soon be totally extinguished; but the more it is determined and confined to the object, the greater force it will exert thereon, and *vice versa*. Thus when the rays of the sun are collected by a burning concave, and all are directed to one point, called the *focus*, their force is exceeding great, and productive of wonderful changes in bodies. And the like is practicable in furnaces; the best whereof are reckoned those which afford the greatest or most suitable degree of heat, with the least quantity of fuel. There are various kinds of chemical furnaces, both portable and fixed, described by different authors; but the most commodious, and generally useful, or those proper for our succeeding course, are the following.

Fig. 1.
Plate II.
The athanor.

1. The first which occurs, as affording the most temperate and equable warmth, is the *athanor*, otherwise called the tower-furnace, the philosophical furnace, and *furnus pigri Hemici*; the heat whereof may be made not to exceed that of the human body in a healthy state.

Its structure may be this: Erect a concave parallelopiped, as *ABG*, of any proper material able to endure the fire; let an iron-grate be placed therein at *FE*, and above this let there be a hole of any size at *DK*, thro' which the air may enter so as to direct the action of the fire between the two sides *F, E*.

Suppose, also, a plate of iron, in this case usually called a register, fitted into the hole at *DK*, which by admitting or excluding the air will serve to regulate the fire, or determine the degree thereof.

Now when the vent *AB* is stoppt with a dome or cover of iron, the heat of the fire upon the grate, ascending parallel to the sides of the furnace, and being stopped by the cover *AB*, will be reflected, and kept in; so that we may easily measure the degree of heat by a thermometer; and according as it proves too great or too small, the hole at *DK* may be the more closed up or opened by means of the register. And thus

thus the heat of this furnace may be measured, intended, and remitted at pleasure; for the more air is let in upon the burning fuel, by withdrawing the register, the greater will be the heat, and *vice versa*. And by this contrivance, 'tis possible to keep up an equable and moderate degree of heat, for the space of several weeks; the fire-place CDEF being at first filled with fuel from FE to CD, will consume gradually, letting fall the ashes into the hole G. DHIK is the place of the sand-heat, and LHMN is the chimney. This furnace is of use in all cases where we require one determinate, moderate, and equable heat; tho I have distilled spirit of hartsorn by means thereof, and sometimes, on other occasions, heated the iron-cover, or dome, even red-hot.

2. I have two kinds of *digesting-furnace*, both of my own contrivance; the one made of potters clay, the other of wood. The first is somewhat roundish or cylindrical; and in its fire-place receives a square tile, made of the same kind of clay, whereon I place a glowing coal, first burnt till it yields no more smoke, and afterwards cover it with clean turf-ashes, sifted lightly thereon, without pressing them down, to the thickness of an inch. Then shutting the fire-place with its door, I can by this means preserve an equable heat, without diminution, for several hours, or till the glowing coal is totally consumed; after which a fresh one may be substituted. The vessel containing the subject, being placed at the top, is to be covered with a dome, having a round hole in the middle to give passage to the neck of the vessel, so as exactly to fill up this upper aperture of the furnace, and lie with its neck bedded in a cavity made on purpose to receive it. Things being in this posture, the fire may thus be kept equable at little charge, without any need of a chimney, and without smoke or other inconvenience. This furnace is principally useful when any digestion or distillation is to be performed with a gentle heat, that ought not to be remitted. And thus I have sometimes continued an operation of this kind for nine months together.

Digesting-furnace.
Fig. 2.

3. My *wooden digesting-furnace*, is made in the form of a parallelopiped. Its structure is now generally known, and much the same with the foregoing. 'Tis highly useful on many occasions, and labours under but one inconvenience; and that is, being made of wood, 'tis apt to crack with the heat. The fire in it is maintained with very little expence, and may long be kept in an uniform degree, without any considerable variation, so as to make plants grow, &c.

4. The *simple furnace* for the *cold-still*, made use of in drawing the odoriferous, or exhalable waters of recent vegetables, is made in brick-work to receive a shallow, copper body, fitted with a large, conical, pewter head, to condense the vapours raised by a gentle heat, and turn them into liquor, to be transmitted into the receiving-vessel thro' a rostrum fixed to the side, near the bottom of the head. By means of this ind. of furnace, we come to know what it is which spontaneously

Cold still.
See Fig. 6.
Plate I.

spontaneously exhales from vegetables by the warmth of the summer's sun, &c.

Hot-still, or
copper-alembic.

See Fig. 7.
Plate I.

5. The common furnace for distilling all kinds of waters, from vegetable or animal substances, is of admirable use; and is made to receive a copper body, placed in the midst of brick-work, after the manner of a copper for brewing, with its metalline head; the beak whereof is joined to a spiral tube, or worm of lead or pewter, that runs its winding course thro' a large vessel of cold-water, called the refrigeratory, so that by means of a long descent thro' such a vessel, the distilled liquor is made to come off cool, tho the matter in the copper-body should boil ever so fast; whence it does not endanger the breaking of the glass-vessels, which here perform the office of receivers, as it would do, were it to come over boiling hot into them. This furnace greatly shortens the work of distillation, and renders that performable in a few hours, which otherwise could not be effected in the space of many days. But when the matter to be distilled is volatile, and requires only a small degree of heat to raise it, there is no occasion for the worm and refrigeratory; but the liquor may immediately be received in a proper vessel, as it falls from the rostrum of the still-head, or from a tube that passes without winding thro' the refrigeratory.

Balneum Maria.

Fig. 3.

6. The bath-furnace, *balneum maris*, or *balneum Maria*, is a copper body of water, receiving another fitted with its head or alembic; and this compound alembic is to be so placed, that the fire applied may make the water boil; which being constantly kept in that state, will afford the same uniform degree of heat, tho the fire be great or small. This furnace is of use in distilling all kinds of subtiler or volatile spirits and waters, as those of roses, &c. without danger of spoiling their flavour by burning them to the still; as also in rectifying spirit of wine, &c.

Sand-furnace.

Fig. 4.

7. The sand-furnace is designed to convey heat to the vessel by the interposition of sand, which, being contained in an iron-pot, receives the action of the fire below. This is used where we require a greater degree of heat than can be given by boiling water; and may be raised so high as to melt the vessel, or make it red-hot*.

Wind-furnace.

Fig. 5 and 6.

8. The wind-furnace, melting-furnace, reverberating-furnace, or assaying-furnace, is designed to give the most violent degree of heat, which may best be effected by making it of an elliptic figure; provided the furnace be so contrived that the grate stands in one focus, and the vessel containing the subject in the other: for as it is the nature of fire to go off every way in straight lines from the centre to the circumference; 'tis manifest from mathematics, that all the rays which go from the lower focus of the ellipsis to the circumference, will from thence be reflected to the upper; and consequently, if the fire be placed in one focus of the ellipsis it will produce a violent degree of heat in the other. And

* The filings of iron are sometimes used instead of sand, for this purpose, as conceiving a much greater degree of heat than that.

PLATE II. CHEMICAL FURNACES. *To face p380*

Fig. I. Pag. 378.

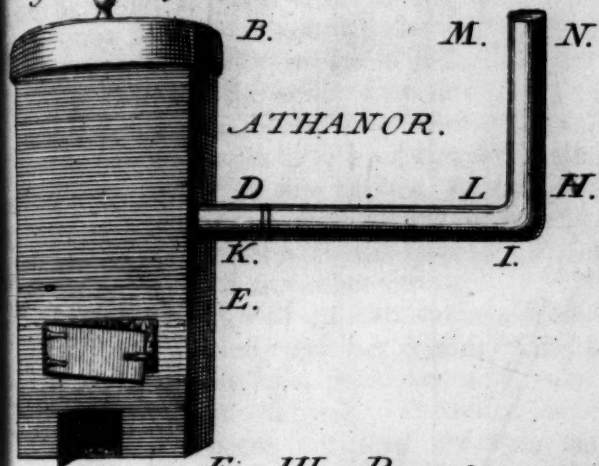


Fig. II. Pag. 379.

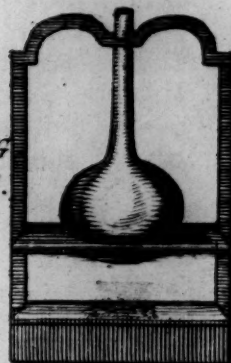


Fig. III. Pag. 380.

Fig. IV. Pag. 380.

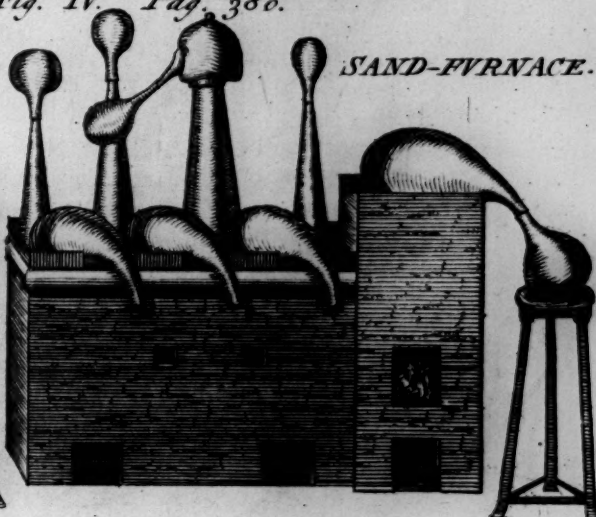
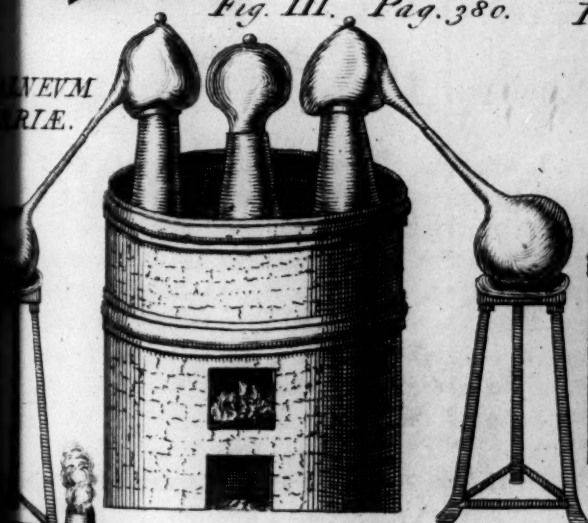
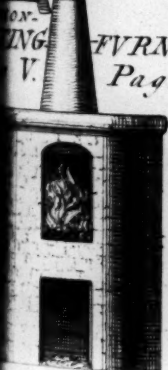


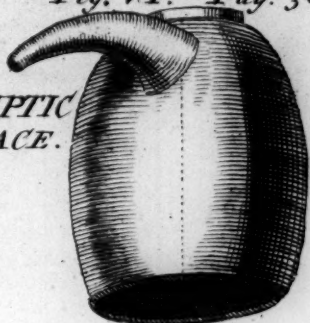
Fig. V. Pag. 380.

Fig. VI. Pag. 380.

Fig. VII. Pag. 381.



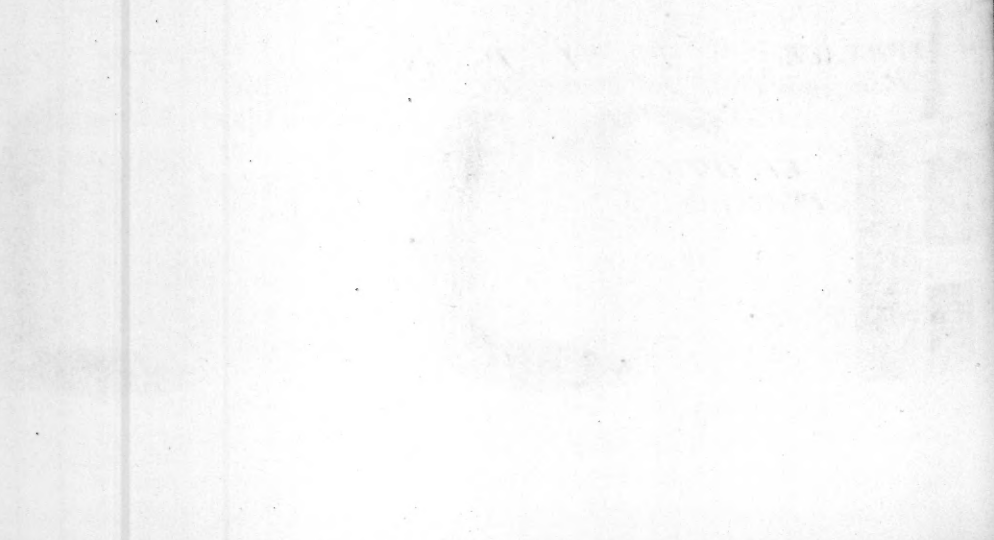
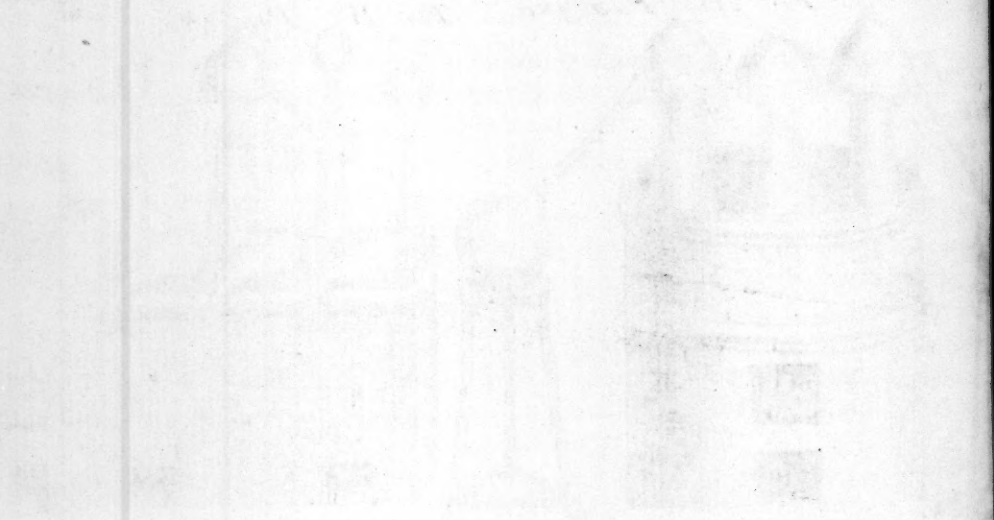
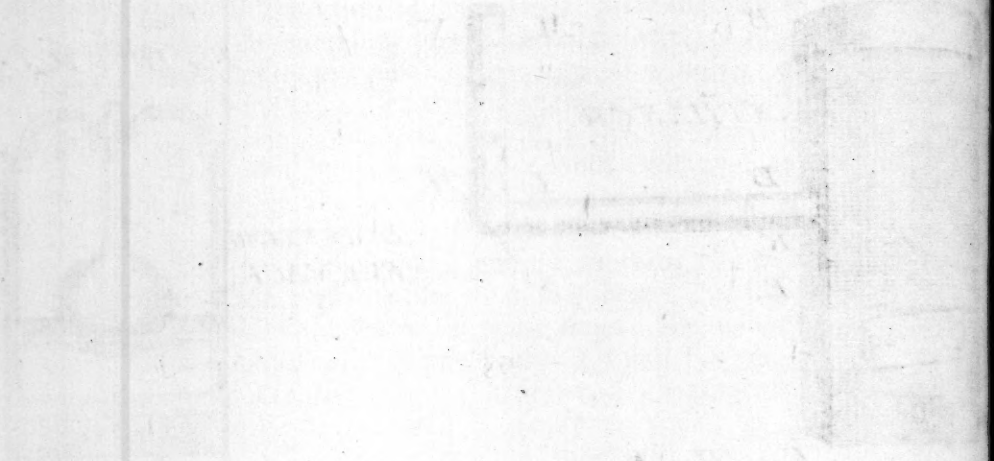
ELLIPTIC
FURNACE.



PARABOLIC
FURNACE.



THE CHEMICAL JOURNAL



the
for
le
th
th
be
ha
th

after the same manner a furnace may be erected for distilling acid spirits, or the like, with a naked fire and earthen retorts.

9. But of all the various kinds of furnaces invented by chemists, the parabolic are those which throw the greatest heat upon the matter to be changed, in proportion to the quantity of fuel employed. These are built in such a manner, as that the plane of the grate may pass thro' the extremity of the *abscissa*, and be at the same time perpendicular thereto; the vessel containing the subject, being placed in the focus: for 'tis mathematically demonstrable, that all the rays, which here tend perpendicularly upwards from the plane of the grate, after they once arrive at the surface of the parabola, are thence reflected back to the focus; where they produce the greatest possible degree of heat, in proportion to the quantity of fuel; which is not so true of the furnaces of any other figure. Parabolic furnace. Fig. 7.

But a knowledge of all the various kinds of furnaces, is better acquired by inspection, and being conversant in the laboratories of chemists, than by any description we can give of them*: tho what is here delivered upon the subject, will suffice for our purpose, and furnish us with all the furnaces we need hereafter employ in our course of operations.

LUTES.

BT the word lute, chemists understand such a matter, as being spread upon the junctures of communicating vessels, will exclude the external, and keep in the internal air. Such a matter is requisite to the due performance of distillation, in which the vessels concerned are so strictly to be joined together, as that no part of the contained subject may perispire, or be lost. The lute, or cement, commonly used in the distillation of inflammable, alkaline spirits, waters and other liquors, which are not of an acid nature, is made of linseed meal, well cleared of its oil by expression, and mixed up into a paste with as little water as will suffice for that purpose. This is an admirable kind of lute; for being spread upon the junctures of vessels, it presently acquires the hardness of a stone; and yet upon occasion, may be readily shaved off again. But in the distillation of acid spirits, we must have recourse to a lute of a different kind, called by the name of *lutum sapientia*, or the luting of

The common lute.

The philosophic lute.

* The business of furnaces, tho it has been treated of by almost all chemical authors, seems capable of great improvement. A knowledge of mathematics, and of the properties of the air and fire, will enable us to construct them to more advantage than hath hitherto been practised among chemists; who seldom happen to be masters of more knowledge than they get out of the fire. Those here described

will serve very well for the common purposes of chemistry, or the following course of experiments; but the larger work requires a suitable contrivance, to lessen the expence, and yet perform the operation in as great perfection as if it were done in miniature: but this consideration belongs to the trader more than the artist.

the philosophers; the common sort being not all fit for this purpose. The philosophical lute is composed of colcothar, or the *caput mortuum* of vitriol, boiled in several parcels of fresh water, till the decoction at length becomes insipid, or retains no saline part of the colcothar; which being now reduced to a perfectly dry powder, and kept a-part, may be mixt occasionally with an equal quantity of quick-lime, and a small proportion of the white of an egg, first well beat with a spoon, so as to make the whole, with great expedition, into a paste, to be used the moment it is formed; otherwise it will grow too hard and unfit for use. This lute being thus rightly prepared, and seasonably applied, will by heat become as hard as glass it self, and suffer no liquor to escape it. But in case it should crack, as it sometimes will, new must be applied, to fill up the interstices. But there is a much readier way, which I sometimes use, of making a paste for this purpose; which consists only in taking a proper quantity of potters-clay, and working it up with sand, between the fingers, till it will no longer stick to them; and this with as small a quantity of water as possible. Glasses being luted with such a composition, which is afterwards to be dried upon them, and the operation repeated or amended, if any cracks should happen in it, will, in some cases, be kept sufficiently close for the purpose above-mentioned. Or a still shorter and easier way may be to soak a hog's bladder in water till it begins to corrupt, and acquire a nauseous scent; which being afterwards applied to the junctures of glass-vessels, and gently dried, will stick almost as fast thereto as if it self were a part of the glass.

Mr. Boyle supplies us with an excellent cement to strengthen and hold crack'd glasses together, so as to fit them for farther use. This cement he made of the fine shavings of old fat cheese, and an equal quantity of quick-lime, worked together with a little water, and spread, like a plaister, upon linen, to be applied along the crack*. But the cheese and the quick-lime are to be kept separate, and not to be mixed till the cement is wanted; and then, too, the mixture must be made with great expedition, or else it will grow hard and unfit for the office.

Lute for coating of retorts.

When cracks happen in the furnaces, they are to be filled up with a lute or cement made of sifted ashes, and a small quantity of water, well mixed and worked together; for a paste thus prepared, will admirably close these gapings, and at the same time endure a most violent heat. There are several occasions in chemistry which require the use of glass-vessels

* There is another cement made use of by some chemists of London, to answer the same end, consisting of sifted wood-ashes, beat up to a due consistence with the white of eggs, and a little gum-water. The same service may, in a more excellent manner, be had as well for cracked glasses as broken china, or the like, from what the painters call drying oil, or a mix-

ture of linseed oil and ceruse, made, by insolation or decoction, into a perfectly white balsam, and afterwards ground upon a marble with fresh ceruse, till the whole is perfectly fine, and become of the consistence of an unguent. This dries slow indeed, but is very effectual.

in a naked fire, whereby they would be made to flow, unless defended from the violence of its action; as they may be by means of a cement, already mentioned, made with potters earth and sand. Thus in the separation of quick-silver from other metals, wherewith it is amalgamated; in the recovering of the sulphur from cinnabar or æthiops mineral, in the preparation of *Ens veneris*; or, in the like cases, we are obliged to give our retorts a case to keep them from melting in the fire. This case for their defence is made by mixing such a quantity of common sand with potters clay, as will suffice to take off its unctuosity, and prevent its sticking to the fingers; then with a small quantity of water, it may be reduced to a paste, which being spread to the thickness of half an inch, or less, upon the whole external surface of a retort, and set in a warmish place to dry gently, it will become hard, and enable the glass to endure a strong naked fire. But if, in drying, the paste happens to crack, it must be mended with some of the same, as before, and dried rather more gently. And this method of defending retorts, is, among chemists, called by the name of *coating*.

These are all the kinds of cements absolutely necessary in the practice of our art: and thus, at length, we have distinctly gone thro' the whole *apparatus* or *theory* of chemistry, and are now prepared to proceed to the practice.

End of the THEORY.



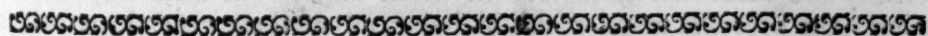
Part II.



PART III.

THE PRACTICE OF CHEMISTRY,

Exhibiting a chain of processes, perform'd, by the agents mentioned in the second part, on the several subjects of the three kingdoms, vegetable, animal, and fossil; in a geometrical method, proceeding, step by step, from the most simple and easy operations, to the most complicated.



INTRODUCTION.

WE are now prepared to enter upon the third and last part of our undertaking; the performance of those operations whereby a chemist directs his inquiries into natural bodies; and from whence he forms his doctrine about them. Chemical operations, otherwise called processes, are no more than particular methods of changing the bodies described in the foregoing theory, by means of the instruments there enumerated, so as to render the changes they suffer observable to the senses. Or, more particularly, a chemical operation is such an application of
A fire

INTRODUCTION.

fire to any part of the *materia chemica*, as may effect a change therein, yet leave it capable of being compared with what it was before.

The principal reason why chemistry has been condemn'd and slighted by some men of eminence in the world, is the bad order hitherto observed in delivering these processes or operations. For, chemists have given us the history of their experiments in such a diffusive, tumultuary and miscellaneous manner, as renders them excessively disagreeable, tedious and un-instructive. When they treat different subjects, of the same class, in the same or a similar manner, they would have their readers believe they give them different processes; but, in reality, the case is otherwise: and were it not, yet to a learner it would be no more than an idle and useless repetition of the same thing. In order to instruct a person how to distil the water, or gain the essential oil, of any plant whatsoever, he need only be taught the method of doing it in rosemary, for instance, and not in a thousand different herbs; which would be multiplying examples to no manner of purpose; because all other vegetables are to be managed in the same manner, with the same instruments, to the same end. We, therefore, purpose to retrench this redundancy of the chemical writers, and only give the necessary, the useful and instructive part of this valuable science, in a select number of general processes, ranged in strict geometrical order. Beginning with such as are most simple and easy, we shall proceed, step by step, to the more difficult, complicated, and laborious; so that the first will lead to the second, the second to the third, and all have a mutual connexion with, or dependance upon, one another: whence the whole number, taken together, will make an entire chain, or system, of chemical operations; every one whereof is a canon, example, or standard-rule for performing all others of the same kind. The advantages of such a method are very considerable; for it will never suffer us to omit, in the foregoing, any particulars necessary to the subsequent processes; nor oblige us to repeat any single operation: so that by this means, tho' the objects of chemistry are numberless in every class, and the changes to be wrought upon them infinite, we shall clearly and satisfactorily exhibit the whole art, in one collected, uniform view; the processes made choice of being all of them general, as well as particular; and together shewing the manner of performing all sorts of chemical operations; being themselves the elements of the art.

The general manner in which such a course of processes ought to be conducted, is, (1.) Strictly to survey, and examine every subject, with all our senses, before 'tis committed to the operation; and, as much as possible, to keep to the same subject in different processes. For if we should draw our oil from rosemary, our water from mint, our salt from lavender, and so make use of a new plant for every operation, we should run into great confusion; and never learn all the substances obtainable from any one vegetable. (2.) To describe the operation, and the manner wherein it is to be conducted. (3.) To
give

INTRODUCTION.

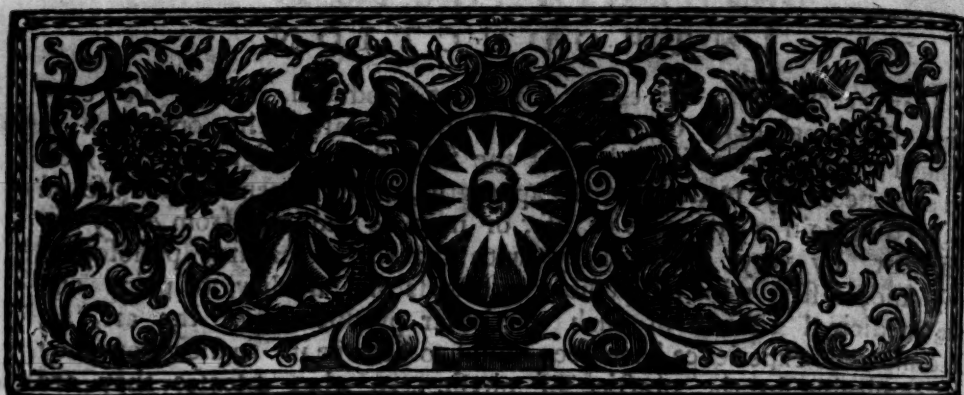
3

give an account of the effects that are produced. (4.) To examine the remainder, or what is left behind after the operation is finished; and compare it with what the subject was originally. (5.) So far as is necessary, to describe the apparatus, or instruments, made use of. (6.) To subjoin what arises of use, or may be deduced, from every experiment, by way of corollary, with regard to natural philosophy. (7.) And, lastly, with all possible exactness and fidelity, to point out the medicinal virtues of such particular productions of the art, as, by competent experience, have been found to deserve it; to shew how they are applicable in the practice of physick; to what diseases they are particularly suited; and in what doses they ought to be given. But we are not to expect that every chemical operation must needs present us with some excellent medicine or other, as the major part of chemists have fondly imagin'd; for this art is so far from being a slave to the narrow views of pharmacy only, that it deserves to be united with many of the nobler sciences; and, in particular, with natural philosophy, of which 'tis, without dispute, the principal branch.



A 2

SECT.



S E C T. I.
Exhibiting a Course of PROCESSES upon
VEGETABLES; the most simple and re-
soluble of Organical Bodies.

The Fundamentals of the ART;
Shewing in what manner the Chemical Analysis of Bodies
is to be undertaken.

*A vegetable
 subject to be
 chose for the first
 process in che-
 mistry.*



THE order we have prescribed ourselves requires us to begin our operations with a subject, which, of all others, is at once the most simple, easiest resolvable, or whose parts are separable by the smallest force, and such as will serve for a basis to the experiments that are to follow: it can, therefore, be no other than one taken from the vegetable kingdom; for, bodies of this class are resolved, analysed, or chemically treated with more ease than animal or fossil substances. Vegetables, also, are of a more simple structure than animals; whose bodies being composed of the former, makes the knowledge of vegetable subjects

Processes upon Vegetables.

5

jects requisite to the understanding of the animal : whence our inquiries into their nature ought to begin with vegetables. 'T would be highly improper here to set out with fossils ; for, tho' these are more simple, or inorganic, than the bodies of animals and vegetables ; yet they want several other qualifications : in particular, they require too great a violence of fire to work upon them ; and suffer too great a change in their resolution, to be fit for this purpose. At first setting out we require only a bare separation of the parts, and not a perfect transmutation of the subject. Gold is a very simple body, indeed, but exceeding difficult to analyse. On the contrary, recent vegetables contain a water, which evaporates with a very gentle heat, and is therefore easily obtainable ; whence these are much properer subjects than fossils, to be first treated in a course of chemistry ; and ought likewise, on account of their simplicity, as well as the share they have in composing the bodies of animals, to precede them. But the plant made choice of for the subject of our first operation, should be fresh gathered, and in its perfection ; otherwise it would not afford the volatile part we ought to gain from it. By making choice of such a subject to begin with, we shall obtain a method of examining into the composition of all bodies, by separating them into the parts, or simple substances, whereof they were originally composed ; or of taking bodies to pieces after the same manner as they were naturally put together. To know what the body of an animal is, we ought first to know what it feeds on ; and, if we would know the composition of human blood, we ought first to be satisfied as to the food made use of by mankind : and the food of all animals consisting ultimately of vegetable substances, 'tis evident we should begin our processes with these.

2. The instrument of the first operation, or the thing which the artist directs and applies to give the motion made use of in it, should be (1.) most pure and simple, or such as will impart but little of itself to the subject. (2.) It should be universal, or such as may conspire in every future operation. (3.) It should introduce but very little change in the subject. (4.) And, lastly, it should leave the separable parts distinct, or blend them but little together. To all which characters there is nothing so well entitled as a clear, soft, equable fire. Fire is the general instrument of chemistry ; and therefore a small degree of it will very well coincide, or consist with the greater, required in other operations. And a gentle fire will not much confound, but only separate the parts of the subject. Thus, if quantities of spirit of wine, water, oil and salt were mixed together, and the whole exposed to a soft heat, the spirit would rise first, the water next, the oil third, and the salt last ; provided the heat were strong enough to carry it up : whereas, if a vehement fire had been at first employ'd, the several bodies would have all risen confusely together, and no instruction have been reap'd from the process. But, a clear, soft, equable heat, applied to a fresh-gathered plant, or volatile vegetable subject, will produce distinct and clear

What instrument is to be made use of in it.

Processes upon Vegetables.

clear effects; the uses whereof are very extensive, and serve to instruct us in the nature of all other chemical operations.

What are to be the properties of the first process.

3. Again, our first process should be, (1.) independent and absolute; or require no other to precede it. (2.) It should be performable with the greatest ease. (3.) It should be exceeding simple, or the least complicated of any known operation; and consequently must require the fewest agents, the smallest action, and the least apparatus. (4.) It ought, as was said of the instrument, barely to separate the parts of the subject; and by no means to alter, confound or transmute them; but leave them in such a state, that farther experiments may either be made therewith, or when joined together again, they may nearly exhibit the thing as it was at first. This is the true nature of separation, whose office it is to preserve the genuine parts of a compound distinct, without alteration. Motion is the universal cause of change in bodies, except in those that are elementary; and, according to the degree thereof, the greater or less alteration it occasions. 'Tis possible, by motion, or fire, to change a body so, that it could no longer be known for the same. Thus, rosemary could not be known for such, if it were reduced to ashes: whence 'tis very ill concerted of those who make calcination the first operation in chemistry.

The advantages it shou'd afford.

The advantages to be gained from a process having the qualifications above-mentioned, are, (1.) A knowledge of the separated parts, or ingredients of the subject; which being barely separated, not changed, there can be no doubt that they before existed in it. (2.) A knowledge of the remains, or the parts left behind after the operation is finished; which could not be had if the subject were greatly changed: for if wormwood should once be reduced to ashes, we could not distinguish them from those of any other plant. But when a process is carried on by mere exhalation, and the subject loses nothing of its form, only appears somewhat dry and shrivel'd, no body can question whether what was thus obtained from it once made a part of the subject. (3.) The power of examining the remainder by new experiments. For a mild and gentle operation will only take away the parts that were easily separable, and leave the others entire. Thus, after the volatile, or aqueous part is drawn away from a plant, we shall find the remainder dry, perhaps, and shrivel'd; but still possessed of its former figure, and capable of farther examination. Which gentle way of proceeding is admirably suited to discover the composition of bodies: but to expect the same advantages after a violent operation, were to look for snow in the dog-days. (4.) And, lastly, we shall hence gain a clear and distinct idea of the instrument employ'd, and the action it performs. All which particulars will be fully illustrated in the first process it self.

4. When, therefore, the most simple action of the most simple instrument is applied, or determined, to a most simple vegetable subject

Processes upon Vegetables.

7

ject, as above described, the change produced thereby will be small and simple, yet discernible, clear and distinct. But the nature and effects of this operation are to be well considered, before we proceed any farther; for no other process can possibly be understood without the assistance of this. 'Tis as requisite to the knowledge of all the succeeding operations, as the knowledge of exhalation is to that of decoction. That we may therefore come fully prepared to understand this fundamental operation, we will here inculcate, or repeat, so much of the natural history of vegetables, as seems proper for our purpose.

5. Vegetables consist of two different parts, solids and fluids. The solids, *The vessels of* being either vessels or receptacles, are, (1.) The absorbing vessels, or those *vegetables.* which drink in nutriment from the earth, or air, or something mix'd with either, are seated all over the external surface of every plant; in the root, leaves, bark and flowers: and tho' their orifices are so small, as scarce to be discerned with a microscope; yet the nutrimental juice, which feeds the vegetable, every where finds entrance thereat; and is from thence conveyed to the internal parts. These vessels seem to perform that office in vegetables, which the lacteals, and those of the skin, do in animals. They appear lodged in greatest plenty about the root; but that they also exist in other parts is manifest from hence, that if a lopped willow, for instance, be, without its root, set in a proper soil, it will again shoot, bear leaves, and increase in bulk. The aloes-plant of *America* will do the same, when hung in the air with its root wrapped up in paper. And if the branch of a tree be stripped of its twigs, and set with its top downwards in the earth, it will grow in this inverted manner; so that what was before the apex, now becomes the root; whilst all the shoots strike downwards to the ground. (2.) The moving vessels, or those which carry and propel the fluids, are composed of elastic fibres, which dilate with heat, and contract with cold; by which means the liquors are circulated through them. 'Tis their office to carry away, and distribute the juice drank in by the vessels of the former kind, through the body of the plant, of which they may properly be called the circulating vessels; for in these the crude matter, drank in by the absorbing vessels, is altered, digested, prepared, and at last assimilated into the nature of the plant itself. These circulating vessels seem to be a combination of the arteries, veins and lymphatics of the plant; being placed in the trunk or stock of the tree, and the woody parts thereof, which differ greatly from the flowers, the leaves and fruit: they are also endued with valves to prevent the circulating liquors from falling back, or returning in them. (3.) The air-vessels seem to be distributed every where about the plant, to the end that, by forming into bladders, and contracting and dilating themselves, according as the heat of the sun, and the cold of the night, reciprocally expand or condense the air within them, they may squeeze the circulating vessels in their neighbourhood, and so help to propel their fluids upwards; otherwise they could hardly rise to so great a height as in some trees we see they do: for the sun's heat, by rarify-

Processes upon Vegetables.

rarifying the air at the top, more than it does at the bottom of such trees, could never suffer the lower air to press the vegetable fluids above thirty-six feet high; whereas we daily observe trees rise much higher than that. There seems, therefore, to be occasion for this diurnal expansion, and nocturnal contraction, acting like the systole and diastole of the heart, to throw up the alimental fluids of vegetables; as also for valves to hinder their returning back the same way. And thus these fluids may move briskly in the day-time, and but languidly by night; during which, they therefore appear to rest or repose themselves. And this seems to be requisite for them; since we observe that plants never thrive so kindly in the constant heat of a green-house, as when they enjoy the open air. (4.) The secretory vessels separate the proper juice of the plant from all the rest of the fluid matter brought into it. Thus, the aloes-plant, from one and the same liquor, separates honey in its flowers, and an intolerably bitter juice in its leaves. These vessels are found in the bark, buds, leaves, flowers, and parts the most remote from the roots. It appears to be their office to separate, and change the general fluid of every plant into substances of different natures; as into oil, salt, and water. Tho' the aloes-plant and sugar-cane were to grow near one another, they would separate, and afford very different juices: which seems owing to nothing but a difference in the structure of their secreting vessels. (5.) The excretory vessels breathe out the superfluous, or excrementitious matter, which, being detained, might prove injurious to the plant. These vessels are placed every where in the surface, or bark of the vegetable. Thus, we cannot doubt that there are emunctory vessels in rosemary, for instance, which is continually diffusing an odorous atmosphere around it. And thus, in the summer season, when the air is greatly heated, all aromatic and odoriferous plants come to exhale vast quantities of their fine, spirituous and volatile parts.

Their recep-
tacles.

6. The receptacles, or receiving vessels of vegetables, which contain the secreted humors, are little cells, wherein is deposited and lodged the oil, or unctuous part; as the fat of the bodies of men adheres to its cells: for plants have their *panniculum adiposum*, or covering of fat, as well as animals; and over this a bark or crust, which answers to the skin in man. And since, in general, the most fragrant part of vegetables resides in their flowers, and not their leaves; it is evident there are receptacles placed in the former, to receive and preserve their odoriferous matter.

Thus we see, that the solid vessels of vegetables are either such as drink in moisture, such as have a degree of motion, or form themselves into air-bladders, such as perform the office of strainers, such as discharge and throw off the excrementitious parts into the air, and such as lodge some particular secreted juice, or humor.

Their various
juices.

7. All these different kinds of vessels appear to contain different sorts of fluids, which are either aqueous, saline, oily, spirituous, gummy, balsamic,

Processes upon Vegetables.

9

mic, or resinous; all which may be artificially obtained from vegetables. The aqueous fluids are generally found in the absorbing vessels, but mixed with a large proportion of salt, which, tho' always soluble in water, otherwise appears of very different natures in different plants; being sometimes fix'd, as it were, and sometimes volatile; as particularly in scurvy-grass and horse-radish. Even the dryest vegetables hold a proportion of water. Thus, rosemary, which appears to contain but very little moisture, affords a considerable quantity by distillation. But all vegetables abound most with salt and water, in the spring of the year. The oily part, that is, the part which grows fluid at the fire, proves inflammable, and will not unite with water, is, always found in the receptacles of a plant; but in the greatest plenty during the autumn: at which season, the timber designed for building is, therefore, generally fell'd; as then proving the most durable and fit for use. But this oil is never to be obtained pure from vegetables; some quantity of salt, water, earth, or other substance, being always mixed along with it; which is the reason of its turning rancid. The spirituous parts, or those which contain the odour and taste of the plant, are very volatile, will mix with water, and sometimes burn in the fire; the oil of the vegetable being here greatly attenuated, broke, and subtilized. Inflammability, however, is no way requisite in a spirit: those generally called by the name of acid spirits, tho' they extinguish fire, are as much spirits, as highly rectified spirit of wine, which is wholly inflammable. Gums are such productions of vegetables, as will mix with water, dissolve over the fire, and burn away; being tough, viscid substances, and containing a large proportion of the oil and salt of the plant. Balsams are the native oils of vegetables brought to a thick consistence; but containing a proportion of an acid spirit and salt. However, they differ greatly from the oils they afford. Thus oil of turpentine is a very different thing from the balsam, or turpentine itself. Rosins are such productions of vegetables, as, being hard and dry, prove brittle in the cold, dissolvable by heat, inflammable and miscible with oil, but not with water. The weepings or tears of vegetables, or the juices which distil from them when wounded, are either aqueous, as in the birch-tree, pitchy, as in the pine-tree, or somewhat acid, as in the vine.

8. These liquid parts of vegetables greatly differ from one another, *The difference between them.* in various respects; being, (1.) of different tastes in different plants, or different parts of the same plant. Thus the juice of the aloes-plant is exceeding bitter; whilst that of the sugar-cane is sweet: and this will be the case, tho' different plants grow ever so near to one another; or draw their nourishment from the same spot of ground. And the like is true of different parts of the same plant. Thus in the sugar-cane, the juice of the pith is sweet, but that of the bark sourish. The thorny *African* aloes-plant yields a saccharine juice in its flower;

B

whilst

Processes upon Vegetables.

whilst that of the leaves is bitterer than gall. In general, oil resides principally in the bark of vegetables, water and salt in the wood, and a mixture of fine [volatile] salt and oil, or spirit, in the blossoms or flowers. It must needs, therefore, introduce great confusion to say that a plant is possessed of any one particular taste, or virtue; since those will vary in the several parts thereof. But we may establish it as an axiom, or general truth, that the nearer any juices of the same, or different plants are to the absorbing vessels, the more similar they will be to one another; so that I make no question, the juices contain'd in the absorbing vessels of liquerise and coloquintida, or the bitter apple, are nearly of the same nature and properties. (2.) These juices differ also in point of colour. Thus, in lettuce, the sow-thistle, succory, goats-beard, poppy, the sparges, &c. the juices that ouze out of them, when broken, are all white and milky. But if from euphorbium, or any species of the sparges, a leaf be broken off, the acrimonious, or biting, milky juice that ouzes out, where the separation was made, being exposed to the air, becomes black and poisonous. Such a juice will continue to flow spontaneously from one of these wounded plants, so long as no heat, by contracting or blocking up the vessels, or thickening the juices in them, joins the lips of the wound; by which means it is that the flux comes to be stopp'd. But the juices, flowing in the same manner, from the ripe aloes-plant, or from celandine, are of a yellow or golden colour; tho' these, and all other plants, when bruised, afford a green juice by expression; which is the predominant colour of them all. Upon wounding the red beet-root, there ouzes out a very pellucid liquor; but when the same root is bruised, it affords one that is exceeding red. In most poisonous plants, the juice is first white, then yellow, and black at last. And thus too in the same vegetable, the juice of the fruit is of a different colour from that of the leaves or flowers; as appears in the strawberry, the mulberry, the cherry, &c. (3.) They differ again in point of scent. The exhaling vapor, or juice, of the rose smells differently from that of the jasmin-flower; and that of the violet from that of the carnation. The juice of the leaves of the jasmin-tree hath scarce any scent at all; whilst that which exhales from the flowers is wonderfully fragrant. And every vegetable has a different and peculiar smell in its bark, root, leaves, stalk and flowers, which distinguishes it from all other plants. 'Tis observable, that the farther the parts are removed from the root, the stronger is their scent; which also holds true of their taste. But if a plant be bruised, or its vessels broke and confusedly jumbled together, it no longer retains its specific scent. The carnation, and the rose, whose fragrance is so delightful, lose it all, if once they be crush'd between the fingers. The lilly is fragrant in its flower, but fetid in every other part. (4.) Lastly, these vegetable juices greatly differ with the climate and season of the year. Thus in the spring-season, before the fruit is ripe, its juice proves rough and acid upon the tongue,
but

Processes upon Vegetables.

II

but soft and sweet in the summer, when 'tis arrived at maturity. Cherries, mulberries, strawberries, barberries, &c. are green at the first, then white; but afterwards turn red by degrees. All vegetables, during the time they bud, and put out their leaves, scarce afford any scent at all; but many of them, when they flower, yield a delightful fragrance. And 'tis universally true of plants, that their juices in the spring are watry and saline; but more compact, and better elaborated in the autumn. Thus, likewise, most plants in the winter-season, prove watery, when the frosty weather breaks, and afford neither an agreeable scent, nor any volatile oil. The garden-carot, when first it sprouts from the seed, appears green in its leaf, and white in its root; but when come to full maturity, the root is red, and the leaf turns yellow. The Italian night-shade bears poisonous berries, that vary in their colour with the seasons of the year, and the growth of the plant. The rose-tree, whilst it blows, yields no scent in any part but the flower: and there are some flowers that afford no odour at all, till they come to open; but, are then exceeding fragrant: which is particularly the case of jasmín. Cherry-trees, whilst in bloom, breathe out a most pleasing fragrance; but their fruit affords no scent at all. And the like may be said of many other vegetables, as well with regard to their taste, as their odour. After the same manner, likewise, the juices of vegetables vary in their medicinal virtues. The exhalable vapor of damask roses proves cardiac, or refreshing; whilst their express'd juice is purgative. Green fruit is found prejudicial to the body, but very wholesom, when fully ripen'd: and experience teaches, that all vegetable juices differ with the climate, both in their taste, scent, colour and medicinal virtues. *Helmont*, therefore, might well say, "there is as great a difference between a plant and its juices, as there is between an animal, and the blood that runs in his veins."

9. Among all the different kinds of vegetable juices, above-mention'd, there is one which constitutes the most noble and fragrant part of the plant; and which having undergone all the necessary changes and secretions in the several organs, and felt the requisite heat and effects of the sun, is at length, during the summer-season, gently breathed out from the emunctory vessels on the surface, after the manner of an insensible perspiration; or else, as we learn from experience, it is arrested and detained by some other particular parts of the vegetable, and principally the flower. This being a real juice, and by no means any artificial production, but a perfect and elaborate preparation of nature, made to exhale by the mild and gentle action of the summer's sun; we venture to call it the native or presiding spirit of the plant; because it perfectly contains in itself the odour and taste thereof; and widely differs from the spirit which the same vegetable affords by fermentation. The plants that every way diffuse such an atmosphere around them, are principally those of the aromatic kind; which affect

*The most noble
fragrant and
volatile, to be
separated in
the first process.*

Processes upon Vegetables.

the nostrils and palate in a pleasing and delightful manner. Thus on the coast of *Narbonne*, in *France*, the rosemary, which there grows in very great plenty, diffuses such a fragrant atmosphere around it, that sailors are thereby warn'd of their approach to this place, at the distance of three leagues from the shoar. Possibly there may be a great number of inodorous plants, which, in the same manner, send out their exhalations into the air, tho' our senses take no notice of them; for as animals are always surrounded with their own atmospheres of perspirable matter, which they neither see, nor perceive; so 'tis not unlikely that vegetables have the same, or something analogous thereto. But we properly enough call those plants scentless, which our nostrils give us no information of; tho' it would be rash to assert that they are absolutely inodorous to all animals in the world.

The vegetable juice, just now described, being the most volatile, or easiest separable, of all those afforded by plants; 'tis manifest, from what was before deliver'd, that our first process ought to be so directed, as, if possible, to obtain it. We find this juice is naturally made to fly off by the heat of the summer's sun; tho' in a form invisible, and without causing any great change in the plant. But 'tis the business of chemistry to include objects in proper vessels, so as to render the changes, or effects of the operation visible.

Rosemary considered for the Subject of it.

In order then to obtain this juice, or water, let us make choice of the plant rosemary; because it is an aromatic ever-green, that may be had perfectly good, and fit for the purpose, at all seasons of the year. But before it is made use of in our operation, it ought to be carefully examin'd as to its freshness, figure, surface, colour, odour, taste, strength, nerves, or vessels, the furrows of its leaves, and all the other circumstances that can possibly be thought of; for if any particular be omitted, the effects of the process will not be perfectly comprehended or understood.

P R O C E S S I.

Exhibiting the manner of obtaining those waters which spontaneously exhale from recent vegetables, in the summer-season, by a standard example in the plant Rosemary.

The process.

1. **H**AVING accurately view'd and scann'd our subject, and found it to be fresh-gathered, every way perfect, and fit for our turn; we commit it, pure as it is, without any mixture, to a cold-still, or simple furnace, so contriv'd, that it may, for a long time, be uniformly kept in a mild and gentle heat, not exceeding that of the summer's sun, by means of a soft, well-regulated fire; which forcing off the vapor, or most volatile part of the plant, it is condensed by the large pewter head

Processes upon Vegetables.

13

head, and trickles down the sides thereof into a proper vessel, placed at the end of the rostrum to receive it; where it appears in the form of water*.

2. This ascending vapor is not visible during the heat of summer, any *its effects.* more than about the plants, which by the sun are then made to exhale it into the open air; and wou'd entirely fly off and vanish, if the vessel that contains the subject were open: but since it is our business, as chemists, to render the changes we make in bodies observable to the senses, we catch and collect it by means of the pewter head; whereby those insensible fumes are render'd sensible, and prove, when caught and condensed, to be the dewy exhalations or fragrant water of rosemary.

2. The liquor thus collected, we may, when the operation is finish'd, and the vessels disjoin'd, have an opportunity of examining with all the accuracy we are able; by comparing it with what remains behind of the original subject, as also with a fresh and perfect one of the same kind, which has suffer'd no alteration. The result of which examination is, in short, this; that the subject is divided into a liquid and a solid part; that the liquid part is larger in quantity, than could well be expected from so dry a body, and the small degree of heat employ'd for the purpose; that this fluid is the most volatile, fragrant and aromatic part of the plant, wherein its specific virtue resided; that the leaves, which before were full and turgid, are now shrunk and contracted in their bulk; that they have lost their natural taste and odour, and something too of their colour; and appear in all respects, as they would have done, had they lain exposed, for the same space of time, in the noon-day heat of the summer's sun. And hence we learn what manner of vapor is made continually to exhale from aromatic vegetables, during the summer-season; and in what an atmosphere we breathe, when we walk in odoriferous groves and gardens.

3. The advantages of this operation, perform'd in so easy and gentle a *its advantages.* manner, are various and agreeable to those we said were required in the primary process of chemistry. For, (1.) We hence readily gain a knowledge of these parated parts, which, before the operation, undoubtedly went to compose the rosemary. 'Twill admit of no dispute, whether our odoriferous water, which has the specific taste and smell of rosemary, pre-existed in the plant; when 'twas obtained from it by such a mild and gentle operation, as did not destroy the figure of the subject. (2.) By this means also we acquire a knowledge of the remainder. If instead of the moderate heat, here made choice of, we had used such a violent fire as to burn the rosemary, it wou'd, for the greatest part, have been turn'd to smoke or flame; and the rosemary-ashes could not have been known for those of

* It might be proper to perform this operation in a glass vessel, the better to observe the condensation of the vapor, and the gradual change of the subject; without the trouble of unluting the still, or taking off its head at every turn,

this

Processes upon Vegetables.

this plant; but might as well have passed for those of any other. But as the operation was managed by gentle exhalation and exsiccation, without any previous fermentation, or other alteration, no body can possibly mistake the remains of the rosemary for any thing else; especially since the fire, being pure and clear, could not by its smoke, or otherwise, foul, deface or obscure any part of the subject. And, accordingly, the subject still appears to be rosemary; but rosemary dried. (3.) This mild and gentle process gives us an opportunity of examining the remaining matter, by new processes or operations. For after only the water is drawn out of a plant, we may easily try what substances it still contains; and, accordingly, we shall, in the following processes, see what kind of substances are left in the remains of our rosemary. (4.) We hence have a clear and distinct idea, both of the instrument, and the action, of our first process. Thus, when I see any plant whatsoever, which I once knew to be succulent, plump and green, become dry, wither'd and shrivel'd, like the remains of the rosemary of this process; I immediately know that the instrument which thus changed it, was heat: and also clearly conceive the manner wherein it produced this effect: which could be no other than that of our present process; the change procured wherein is evidently effected by heat. And since all manner of plants, except some ever-greens, wither and shrivel up in the heat of the furnace here employ'd; and since we observe, that the same effects are produced by the heat of the summer's sun; we may surely conclude, that the heat of the sun acts in the same manner with that of our furnace. The knowledge hence acquired is the more clear, distinct, and useful, as the operation causes no confusion in the parts of the subject. It is likewise absolutely necessary to begin with, and leads to the understanding of every process to come after it. For whenever I boil, calcine, or otherwise chemically treat rosemary with fire, the volatile water of this process presently exhales away; and therefore, unless I am acquainted with this water, I can never know what the subject is that I am treating, to which it naturally belongs. This operation, therefore, shews us what must of necessity, tho' perhaps without design, happen in all the other processes. (5.) And, lastly, We hence obtain an useful canon, or method for analysing all sorts of bodies; which ought to proceed by gentle and slow degrees, that the most volatile matter may have time to rise first; and all the parts be gain'd pure, distinct, and perfect. But if instead of proceeding thus gently, we had used a strong fire in our process, it would have burst the vessels of the plant, carry'd over such of its parts as shou'd have been left behind, and thereby have corrupted and spoiled the odoriferous water, and unfitted the remaining part of the subject for the next process; so that we shou'd thus have reaped no fruit from our labour. And, on the other hand, if the fire had been much gentler, nothing at all would have been raised from the subject. That such a kind of analysis is just, and separates the actual parts of bodies, might easily be made

Processes upon Vegetables.

15

made appear by thus dividing a mixture of two or more ingredients into its component parts; which may readily be done, by observing the cautions here given.

4. The vegetables which, on account of their medicinal virtues, *The vegetable seem fitted for this operation, are of the aromatic kind, or such as subjects which have a pungent taste and smell; the waters whereof, obtain'd in the manner above set down, are of a pleasing scent, and agreeable flavour. are fit for it.* The principal of them are these which follow.

A CATALOGUE of such aromatic vegetables, as are proper to afford the WATER of the first PROCESS, for medicinal uses.

PLANTS.

Angelica.
Aniseed.
Arimart.
Basil.
Baulm.
Calamint.
Calamus Aromaticus.
Camomile.
Caraway.
Clove-july Flowers.
Coriander.
Costus Odoratus.
Cresses.
Cumin.
Dill.
Dittany.
Fennel.
Feverfew.
Galangal.
Garlic.
Hart-wort.
Hyssop.
Jasmin.
Leeks.
Lilly of the Valley.
Lilly, white.
Lovage.
Mace.
Marjoram.
Marum Syriacum.
Master-wort.
Maudlin-tansley.
Mint.
Onions.
Origanum.
Rosemary.
Roses.
Saffron.
Sage.
Savory.
Scurvy-grafs.
Southernwood.
Tansey.
Thyme.
Tuberoſe.
Valerian.
Wild-thyme.

TREES.

ARBOR Vita
Bay.
Box.
Canella Malabarica; or
Casia lignea.
Cedar.
Cinnamon.
Citron.
Elder.
Fir.
Guaiacum.
Juniper.
Lemmon.
Lime.
Mastic.
Myrtle.
Orange.
Nutmeg.
Peach.
Pine.
Sassafras.
Savin.
Storax.
Walnut.

5. The vegetables generally reputed proper for this operation, being only those of the aromatic kind, the catalogue just now deliver'd, was form'd according to that notion; tho' without denying that plants which have neither smell nor taste, might also be treated in the same manner to useful purposes: for such plants may be endowed with great medicinal virtues in their exhalable parts. But I don't remember to have seen

Processes upon Vegetables.

seen any vegetables destin'd to this operation, but what were remarkable for their taste and odour. Any of the parts of vegetable substances may indifferently be chose for subjects of it, provided they are fresh gathered, as the wood, roots, bark, leaves, tears, gums, balsams, and the buds of trees and plants; but more particularly the feeds and flowers thereof. The water of the common spotted arsmart, obtained after this manner, is an excellent medicine, and proves wonderfully serviceable in case of the stone; for which purpose 'tis recommended by Mr. Boyle.

The composition of the waters obtain'd from them.

6. All the liquors thus gain'd from aromatic vegetables, are not simple and unmix'd, but consist principally of two different parts; viz. a large proportion of elementary water, and a very small one of a most fragrant spirit, wherein are lodged the peculiar taste and smell of the plant. This spirit will be obtained in its utmost purity and perfection, if it be separated and raised up by an exceeding clear, mild, and gentle fire, together with a proper proportion of elementary water; wherein it may be preserved good for a considerable time; provided the vessel that contains it be well closed; and especially if the operation has been twice or thrice repeated by cohobating, or pouring back the water, first obtained upon a fresh parcel of the plant; whereby it will be more fully saturated and impregnated with the sapid and odorous spirit, to which the mere water here proves no more than a vehicle; and which, with a great degree of probability, is supposed the effective cause of the specific, or peculiar virtues of vegetables. We are taught, however, by experience, that waters, which are both scentless and insipid, may nevertheless be possess'd of extraordinary virtues. These odoriferous waters are apt to grow foul or mothery by keeping; that is, they deposite a cloud, or light feculence, which contains the oily part of the water. To prevent which, 'tis a good way to drop into them, when they are first distill'd, a small proportion of the spirit of salt, or rectified spirit of wine. We do not therefore pretend that these odoriferous waters are perfectly pure, simple and uncompounded; especially since they contain a mucous part, without which it seems impossible to draw them. With all our care, we could never obtain a water entirely devoid thereof; or that deserv'd to be call'd perfectly pure and simple. That which has been drawn a year will become insipid and scentless, tho' at first gain'd in great perfection; but still we dare not pronounce what remains thereof to be mere elementary water: for, upon comparison, there will appear a great difference between them. 'Tis not in the power of chemistry to make things, or produce them in the manner that one might wish; all that man can do, is barely to separate and compound the parts of bodies: we are not able to bring any new thing into being, which did not exist before. The native spirit of every plant hath something in it that is specific, and inimitable by human art; and the taste and smell thereof are never pro-

producing *. This spirit, however, we can separate from the body of the plant, in a manner which, tho' not perfect, is yet sufficient for our purpose: and he must be acknowledged the most perfect chemist who can make this separation in the most exquisite manner.

7. To gain these aromatic or fragrant waters in any considerable quantity, and to the best advantage, 'tis proper to draw them off in a copper still, with a large pewter head, in proportion to its body; which will collect, condense and discharge the ascending vapor in the greater plenty. By thus enlarging the capacity of their still-head, the *Italians* have a great advantage over the other *European* nations in distilling odoriferous waters; their climate supplying them with excellent subjects for this purpose, and they treating them after a very artificial manner. A very clear and gentle fire is here to be administered; lest by breaking the vessels of the plant, and confounding its juices, the fragrancy of the water should be impair'd. When therefore any very tender and delicate flowers are submitted to this operation, a quantity of fine, dry sand may be strewed, to the height of an inch, between the bottom of the still and the subject; which should then be placed upon a fine, dry paper, spread over the sand. And this is the way they make use of at *Catalonia*, where they distil the *jasmin-flowers* in so great perfection. If possible, the heat employed should not be greater than that of a summer's noon, which forces out the odoriferous exhalations we then meet with in spicy groves and gardens. With a great degree of cold, odoriferous plants prove scentless; and fetid with a great degree of heat. The subject should be in its perfection, fresh, turgid, vigorous and juicy; or gathered at the time and season when its scent is strongest. Some plants are fit for this operation in all their parts; thus *rosemary* may be distilled entire, because it is all over fragrant; but only the flower of the *rose* should be committed to this operation, because its pleasing odour is wholly confined to that. Either the whole plant then, or some particular parts of it, may be gently cropped, or gathered when fully ripe, without violence, or bruising the vessels. This should be done early in the morning, whilst the cold dew is upon them, and, by shutting up their pores, keeps in their odoriferous and volatile parts. A *rose*, for instance, gathered at this time, before 'tis fully opened, affords a much better, and more grateful water, both in smell and taste, than one that was plucked whilst the noon-day sun shone hot upon it, and expanded all its leaves. The plant must be fully ripe, provided it then affords its scent in the greatest perfection. The *lily* and the *hyacinth* have no scent at all, till arrived at maturity, and full blown, but are then wonderfully fragrant; whereas the *rose* is most odoriferous before it comes to be fully blown. The subject should by no means be any way bruised or damaged in the gathering; for this would prejudice the scent thereof. Thus if a *rose*, for instance, were to be pounded before it was committed to distillation, the

The best way
of distilling
these waters.

* This must be understood with due limitation.

Processes upon Vegetables:

other juices would mix themselves with the odoriferous water, and quite abolish or deprave the scent of it; so that what thus came over, could not be known for rose-water, as having quite different virtues and properties from that when skilfully drawn. Thus, as was before observed, the delightful fragrance of the jasmin-flower is lost, by barely crushing it between the fingers; and the pleasant odour of the lily render'd disagreeable and nauseous: which seems to proceed from hence, that the fine, volatile and odoriferous part of the plant is hereby mixed, confounded, and lock'd up in the more gross and viscid juices thereof. And lastly, the water drawn off should be suffered to rest for some days, closed up in the vessels which first received it; by which means the empyreumatical scent impressed upon it by the fire will wear off, and the liquor become clear and highly odorous.

*The usefulness
of this process
in natural philosophy.*

8. We come next to consider what light is afforded, or what useful truths are taught us by the foregoing operation, with regard to natural philosophy. The process it self, and the production thereof shew, (1.) What it is that exiccation deprives a plant of; viz. it's most subtle, fluid, volatile, sapid and odorous part, wherein its specific or distinguishing characters reside: whence we learn the difference between a fresh and perfect growing vegetable, and one that has been gathered, dried, or exposed to a moderate heat. (2.) What it is that rises first in distillation; or what is the most volatile part of vegetables; viz. their proper spirit wrapp'd up in it's common vehicle, water. (3.) What is the effective cause of the peculiar taste and odour in a vegetable; viz. this native, or presiding spirit, which being drawn away, or suffered to fly off from the essential oil of rosemary, for instance, the oil immediately loses all its smell and taste; and which, without dispute, is but a very small quantity of matter, compared with the bulk of the plant, or its juices; and possibly not the hundred thousandth part of the water that contains it. For should an ounce of rose-water be exposed to the open air till its scent is quite abolished; tho' some of the elementary water must have gone off along with it, yet will the whole loss be scarce sensible upon the balance. Whence some chemists have expressed themselves, as if there were a certain little spark in bodies, which makes them what they are, and lodges it self in their salt or oil. And indeed this native spirit is neither oil, salt, earth nor water, but something differing from them all; as being too small in quantity, or too fine, thin and subtle to be caught alone, and rendered visible to the eye: tho' possibly it is no more than a part of the essential oil, most highly attenuated and subtilized. (4.) We hence learn what it is that constitutes the exhalations or effluvia of vegetables; viz. this same spirit, together with the elementary water which contains it, which is continually flying off from them, during the day time, in the form of an insensible perspiration. That this is no fiction, but happens as really in vegetables out of our furnace, as in those included in it, appears abundantly confirmed from history. We are told of trees in *Brazil*, which in a few hours
time

time kill such persons as sit under them; and of others that variously disorder those who sleep in their shade. Some trees are declared capable of making people hoarse by their effluvia; and others occasion a spitting of blood, or an erysipelas. The shade of the yew-tree is said to be mortal; and the effluvia of the walnut will give the head-ach, stop a looseness, or make a man cottive. To walk in an orange-grove, while the trees are in bloom, gives the head-ach, a cold, and brings on a fit of drowziness. Saffron, if lain upon, will make a man sleep; and 'tis no unusual thing for roses to disorder those who walk among them. I myself knew a man to whom their scent would give the head-ach, a vomiting, a looseness, and at length cause him to faint away. The scent of beans is said to dull the brain; and hence the *Dutch* proverb, "you have had a nap in the bean-field"; which is commonly made use of when a man talks from the purpose. Now, taking these facts for granted, as they cannot all well be denied, our present process shews us how such effects may be produced; viz. by means of the very water here obtained; which, during the day time, and especially in warm climates, is plentifully exhaled from all manner of vegetables, by the heat of the sun, and every way diffused like so many atmospheres around them: and these atmospheres, coming in at the nostrils, or otherwise, may prove either wholesome or noxious to the animals which are in them, according to the nature of the plant they proceed from. If rhubarb and hemlock were distill'd after the manner of our process, the remains of the former wou'd lose the purgative virtue of rhubarb, and become astringent; * and those of the latter put off the poisonous nature of the plant, and prove harmless to the body.

9. The principal use of this first process, with regard to the art of ^{its usefulness in} medicine is, that it shews us how to obtain a water from vegetables, ^{physic.} of great virtue in several distempers; as particularly in case of languor and fainting. For, as there seems to be something of a relation between the animal and vegetable spirits; so in case of depression, dulness, or even hysteric or hypochondriac fits, nothing is more reviving than the odour of some aromatic plants, or the water gained from them by means of our process: which water therefore is frequently used by persons of the first rank in *Italy*, for their artificial fountains, that play at their entertainments. For this water passing out of the large perforated balls of such fountains, in a thousand different, slender streams, diffuses a most grateful odour around the room, without at all offending the head. For the elementary water, which serves the odoriferous matter as a vehicle, proves very agreeable and refreshing; whereas were it wrapped up in inflammable spirits, the playing of such fountains would prove very prejudicial to the nerves. Thus, when nothing else would give relief to an hypochondriacal patient, I have known the bare scent of the jasmin-flow-

* On this account rhubarb is commonly order'd to be torrifed, or roasted, to make it astringent.

Processes upon Vegetables.

er suddenly recover him. But this effect is only to be expected from the native vapor of the plant, or the odoriferous water which is drawn from it. The distilled or essential oil of the very same flowers might, instead of performing such a cure, have caused the head-ach, or otherwise disordered the patient. And whoever attempts to counterfeit the specific scent of these odoriferous waters, by means of the distilled oils of the respective vegetables, must take care he does no mischief with them; for they are apt to offend the head, if long smelt to; being in themselves no more than a receptacle of the native spirit, to which, on account of their viscosity, they afford a proper lodgment, and keep it from flying off too fast. Now, as odours act so strongly upon us, and may be made to affect us so agreeably, it might suggest a quære, whether medicines capable of answering several intentions, might not be exhibited in a new way, which sounds more oddly than it appears irrational, I mean by the nose; which is an organ liable to receive very little prejudice by odours of any kind. 'Twas before observed, that the atmospheres of trees and plants, by this means, variously and vehemently, according to their different natures, affect mankind; whence some are confessedly poisonous, and others wholesome. We have known roses purge by their scent: we frequently see men intoxicated by vapours: and I once remember, that having a patient who was exceeding restless and delirious in a fever; I brought a bough of elder, with the flowers on it, into his chamber; and putting them into some warm water, they breathed out their native spirit into the room, after such a manner, that the man was soon composed, and fell into a quiet sleep; out of which he awaked greatly refreshed, and afterwards recovered.

10. We have been the fuller and more particular upon our first process, that we might lay a firm foundation, and prepare the way for those which are to follow; all which will be conducted after the same manner, tho' without such a tedious enumeration of circumstances.

CHEMICAL HISTORY *of the* Preparations obtainable from VEGETABLES by DECOCTION.

P R O C E S S II.

*Exhibiting the method of making INFUSIONS and DECOCTIONS
of vegetable subjects with water, by an example in the RE-
MAINS of the first Process.*

The process.

1. **U**PON the remains of the first process, pour a quantity of pure rain-water, first made scalding hot by the fire, but under the degree of boiling; and continue them together in the same unvaried degree of heat, over a soft fire, the vessel being

Processes upon Vegetables.

21

being closed, which is called the state of digestion, or infusion, for the space of half an hour; after which time, if the liquor be strained or poured off from the subject, 'tis termed the infusion thereof: that is the liquor prepared by infusion or digestion from it. (2.) If after the subject has been thus digested, or infused, it be boiled over the fire in the same vessel, together with the former liquor, for a due space of time, as about a quarter of an hour; the liquor, now suffered to run thro' a sieve, or other strainer, from its subject, is called the decoction, or *apozem* thereof.

2. The second operation in a course of chemistry ought in all *Observations* respects, to bear a near relation to the first; to be performable *thereon* after the same manner; and to depend upon, or be connected with it; consequently it should be performed upon the same, or a similar subject. We may therefore conveniently chuse the remains of the first process for the subject of this. And, indeed, that part of any vegetable which remains behind, after the first process has been performed upon it, may well serve for the subject of this; because the degree of heat employed, being here much greater than that of the summer's sun, or than that made use of in the first operation, whatever parts would be exhaled thereby, will, in an open vessel, fly off, and be lost to the infusion or decoction; so that the dry'd or preserv'd parts of vegetables may in some cases be as conveniently treated by this process, as those which are fresh and succulent; provided they be not otherwise damaged or corrupted. But then we are not to expect the native spirit of vegetables in such decoctions, or infusions. In order to infuse any fine, fresh, aromatic vegetable, so as at the same time to preserve its odoriferous or native spirit, 'tis an effectual way to perform the operation in a glass-egg, or vial, with such a long neck that the ascending vapor cannot rise high enough to escape. By this means we have rendered infusions much richer, and more serviceable in medicinal cases, than could have been expected from the common method of making them. The water for infusion should not be poured boiling hot upon the subject; because in that case it would dissolve too much of the resinous or oily parts thereof; whereas it is principally the saline portion of the plant that we require from this operation; which portion cou'd not so well be taken up by the water, if it was impregnated with unctuous or resinous particles; for oil in great measure prevents the mixing of salts with water. Besides, if the water here should be poured on too hot, it might, in a manner, burn up or scorch the surface of the subject, and induce such a crust thereon, as would not permit the plant to give out its virtue. On the other hand, if the water be too cold, it will not have motion enough to work upon the vegetable, so as to colour it self thereon, and dissolve its salts. When the water is first poured on, tho' the subject floats upon the surface; yet it should soon sink down, after its more soluble parts.

Processes upon Vegetables.

Effects of the
process when
long continued.

parts come to be extracted by the menstruum; or the air, contained in the parts of the subject, to be forced out by the heat.

3. If upon what remains behind of the subject, after the decoction is prepared from it, fresh parcels of water be successively poured and boiled up with it, for the space of half an hour at a time; a fat, sapid, odorous, viscous, inflammable and frothy matter will constantly be found floating on the surface of the boiling liquor, as long as the water poured on extracts any odour, taste or colour from the subject; or till the water may be poured off from it, as pure, clear and insipid as it was put in. Thus therefore, by repeating the process, and continually scumming off the rising unctuous matter, there may at length be obtained a very large proportion thereof; which, being gently dry'd, will afterwards wholly burn and flame away in the fire: whence it appears to contain the oil of the subject; tho' not pure and unmix'd; for a proportion of salt also adheres thereto; so that in reality 'tis a kind of soap, yet not, like that, capable of dissolving perfectly in water. We are not to take this frothy matter for the recementitious part of vegetables, as some wou'd persuade us; we shall hereafter have an opportunity of better examining into and learning its nature and composition. 'Tis very remarkable, that tho' the subject be boiled with fresh quantities of water almost ever so long, yet some of this unctuous froth is still cast up; so that almost the whole plant seems convertible into it. And by this means M. *Homborg*, as we find in the *French Memoirs*, reduced all the substance of the cocoa-nut into oil; excepting only a very small proportion of elementary earth. This unctuous substance lies obscured in the subject, till the salts are once dissolved and carried off; but after these are separated, it easily rises in the water; and being attenuated by the operation, becomes specifically lighter than that, and therefore floats upon its surface. Now, if after all this vehement action of the fire and water, we come to examine the remaining part of the subject, we shall find its pristine figure the same; tho' the leaves are swelled, and plump'd up by the water which has entered their pores: but if we dry them gently before the fire, they subside again, and appear in their natural size and form. However they are something decayed in point of colour, which is now blacker than we found it left by the first process. They have also lost their smell and changed their taste, which is now bitter, from the oil still remaining therein.

The physical,
and chemical
uses thereof.

4. Hence we learn, (1.) That the utmost force of boiling water is unable to destroy the structure even of a tender plant. Thus, tho' the flowers of the white lily be so exceeding delicate and tender; yet all the force of the fire that can act upon 'em, thro' water, will never change their figure. So that hot, or boiling water can do no more than extract the soluble parts from a plant, but never entirely dissolve it. And this may shew how the stalks and tender parts of vegetables are able to sustain all the action of the sun and rain without being damaged thereby; for the utmost heat

heat of the summer's sun is not equal to that of boiling water. Hence also, by the way, we see the reason why the human body is not dissolved by the heat and motion of the blood and juices; and learn that our solids consist not of saline or other matter capable of dissolving in water. (2.) That an odour and taste may be derived from inodorous and almost insipid bodies. For the decoction of our present process, which is both odorous and sapid, was produced by boiling, with insipid water, the scentless and almost tasteless remains of the rosemary, made use of in the first process: therefore this new scent and taste of the decoction must have been raised from some part of the vegetable, which was fixed with regard to that degree of heat whereto it was before exposed. (3.) That infusion and simple decoction are unable to extract all that is soluble in a plant, by the joint assistance of fire and water. By bare infusion, sometimes the colour and the odour of the subject, but always its taste, remains in the liquor; especially when the plant was fresh gathered, in its perfection, and the operation performed in a close vessel. (4.) That an apozem, or a decoction, differs considerably from an infusion, on account of the greater degree of heat made use of in the former; whereby an apozem is fully impregnated; and saturated with those parts of the subject which are readily soluble in boiling water. And the longer the operation is continued, the blacker the liquor grows, and the less it retains of the natural taste and odour of the plant; especially if the vessel be left open, during the operation. If a decoction be prepared with a violent fire, and in an open vessel, some part of the natural taste and smell of the subject flies off every moment: which is an observation of great importance to a physician. In order to gain the full virtues of *sassafras*-wood by decoction, a proper quantity, as, for example, about an ounce, being first rasped, or reduced into thin shavings, should, in a close vessel, be put to boil in a quart of pure rain-water, for the space of half an hour. If the operation were continued longer, and the vessel not well closed, the scent or fine aromatic volatile part of the subject, would, in great measure be lost to the apozem; but may, by proper management, be fully retained therein. The closer, denser and heavier the subject is, and the more oil or rosin it contains, the less fit it is for decoction, and the longer it ought to be kept in infusion, or digestion, to prepare it for that operation; wherein likewise it must be the longer detained before it will give out its oil. Thus *guaiacum*-wood must be infused for twenty-four hours, and then boiled for six more, before it will yield its rosin by decoction, so as to fit it for the cure of the venereal disease. 'Tis the practice in *Italy* to boil this wood, for the same distemper, till the unctuous froth appears upon the surface of the liquor. And in the same manner we ought to proceed when the subject is exceedingly resinous or unctuous. The fresher, softer, and more juicy any vegetables is, the better is it disposed for infusion.

Processes upon Vegetables.

sion or decoction; but, on the contrary, such as are dry and old, appear less fit for either. In a recent plant, the salt and oil are mixed together; but in dry'd vegetables that have been long kept, there remains scarce any thing but oil: or if any salt happens to stay behind, 'tis so mixed and blended with the oil, as to require a deal of boiling to fetch it out. Thus the guaiacum-wood, as it is fresh cut from the tree in the *West-Indies*, will, in half an hour's time, communicate a larger proportion of salt to the water wherein 'tis boiled, than it would here in *Europe*, where it can only be had dry and hard, by being boil'd ten times as long. And hence, perhaps, it is, that the decoction of this wood proves so much more successful among them in the cure of the venereal disease, than it does among us.

*The subjects
best fitted for
it.*

5. The vegetable subjects which may most advantageously be treated by way of infusion or decoction, for medicinal purposes, are those of the astringent, acid, viscous, or refrigerating kind; the principal whereof are included in the following catalogue.

A CATALOGUE of such astringent, acid, viscous, or refrigerating Vegetables, as are proper to be treated by Infusion or Decoction for medicinal uses.

A CACIA.

Apples.
Apricocks.
Barberries.
Cherries.
Cinquefoil.
Comfrey.
Cranes-bill.
Currants.
Dandelion.
Dwarf-elder.
Elder-berries.
Endive.
Fern.
Fumatory.
Gentian.
Gooseberries.

Ground-ivy.

Hypocistis.
Hyssop.
Knot-grass.
Mulberries.
Myrtle.
Nettles.
Peaches.
Pears.
Pellitory.
Poppies.
Perriwinkle.
Plantain.
Purslain.
Quinces.
Rasberries.
Roses.

Rhubarb.

Scordium.
St. John's-wort.
Services.
Shepherds-purse.
Self-heal.
Sorrel.
Speedwell.
Strawberries.
Sumach.
Tamarinds.
Tormentil.
Water-lilies.
Wood-sorrel.
Wormwood.

Its use in medicine.

6. The medicinal virtues of any of these vegetables may readily be communicated to the blood in the form of an infusion or decoction, and mixing with it, perform their office according to their respective natures. And if such infusions or decoctions are drank down warm, they will be made to act by the general virtue of heated water,

water, which in the human body is highly deobstruent and diluting, as well as by that which is peculiar to the plant; and so prove a means of conveying it farther. But such infusions, or decoctions, shou'd not be prepared from very oily, or very resinous vegetables; for then they could not easily enter the mouths of the lacteals, or other absorbing vessels. That the specific virtues of vegetables are, by this means, carried into the blood and juices, appears from hence, that if any one takes a dose of the decoction or infusion of the thick juice of *casta fistularis*, the urine made soon after will be green; and whoever drinks a draught of the infusion of rhubarb, or saffron, upon an empty stomach, will, in a quarter of an hour after, find his urine tinged of a high yellow, like the tincture of those vegetables. So likewise if a woman, who gives suck, should take the infusion or decoction of senaleaves, her milk would, in two hours time, purge the infant at her breast. Whence it is very manifest, that such medicines readily mix with the blood and juices. But when the medicinal virtues of plants reside not in such of their gross parts as are soluble in warm or boiling water, the infusions or decoctions will have no such effect upon the body. But in order to heighten and improve their virtues, and fit 'em for some cases to which they might otherwise prove unequal; the odoriferous water, drawn from the respective subjects abovementioned, by means of our first process, may be added to the decoctions which are afterwards made thereof.

PROCESS III.

Exhibiting the manner of making ROBS, or SAPAS, DEFRUTA, GELLIES and EXTRACTS; by an EXAMPLE in the DECOCTION of the second PROCESS.

1. **L**ET the infusion or decoction of the last process be first clarified, *The Process.* either by standing in a quiet place, by the strainer or filtre, or by being boiled up with the white of eggs, and then committed to a clean, glazed, shallow, open, earthen vessel, whose sides widen upwards; which is to be placed over a clear, gentle fire, that the liquor may gradually exhale away, and the remaining matter gradually become of a thicker consistence. When a decoction hath been thus evaporated, till one half of it is consumed, the remaining part is called a rob or sapa; tho' sapa, in the language of Columella, Cato and Varro, properly signifies must, or new wine boiled half away in this manner. But we now use it, indifferently, for any fresh vegetable juice, or decoction, which is thus treated. (2.) When a decoction is thus exhale away to a third part of its original quantity, we call the remainder defrutum*:

* The words Sapa and Defrutum are used by Pliny in the converse sense of what we here suppose them to mean; as may appear by the two following passages. Nam siraum, quod alii hepsema, nostri sapam appellant, ingeni non natura, opus est; musto usque ad tertiam par-

tem mensura decocto: quod ubi factum ad dimidium est, defrutum vocamus. PLIN. Nat. Hist. Lib. xiv. cap. ix. Vino cognata res sapa est; musto decocto, donec tertia pars supersit. II. Lib. xxiii. cap. ii.

Processes upon Vegetables.

tho' the ancients applied this word also to wine alone, boil'd after the same manner. (3.) When a decoction is thus wasted, by farther boiling, till the remainder becomes of such a consistence, that a drop of it let fall upon a cold marble, or the like, will there congeal, so as to tremble when 'tis touch'd, or to appear endow'd with an elastic property, we call this remainder a gelly. The same word is likewise applied to the fresh juices of fruits, or plants; as also to the broths of animal substances, inspissated or reduced by boiling to the same consistence. (4.) But when a decoction is exhaled away to the consistence of stiff honey, or so far that, when cold, it will not stick to the fingers, 'tis termed an extract; of which there are two kinds, viz. the aqueous and the resinous; the former whereof is made with water, and the other with spirit of wine. But both of them are saline, fat, bitter substances, and constantly appear of a very black colour. After the same manner may the recent juices of vegetables be prepared into an extract.

How to prepare
subjects for it.

2. When the liquor, or vegetable juice, to be exhaled away into any of these forms, or reduced to the consistence either of a *Rob* or *Sapa*, a *Defrutum*, *Gelly*, or *Extract*, has its gross and feculent, or earthy part so heavy, as to fall to the bottom of itself, and leave the subject pure and transparent, it may be sufficient barely to let it rest in a cool, quiet place, in order to prepare it for the operation; and when it has thus purged itself clear, to decant or pour off the liquor, by inclination, from its sediment, before it has conceived any heat, or run into fermentation. If the feculence be light, and will not readily subside, so as to leave the liquor clear, and fit for this operation; it may be depurated by the filtre, or by being several times passed through a double hippocras-bag, or flannel-strainer; in the pores whereof, all the light feculencies, or grosser matter, which made the subject thick and turbid, will by degrees be lodged; and the liquor pass through clear and transparent. There is a thin or spongy kind of cap-paper also, which is known by the name of *filtring-paper*, very proper for this purpose in some cases. A glass funnel being lined with a sheet of this paper, the liquor that is poured into it will be transmitted, drop by drop, in a great degree of purity. Lastly, when the decoction, or other liquor design'd for the subject of this process, is so unctuous, fat and gross, as not readily to fine itself down by standing in a quiet place, it may most properly be clarified with the white of an egg, after this manner. First, beat or whisk up the white of one egg, or more, in proportion to the quantity of your liquor, to a froth, in a clean vessel by itself, and afterwards work in a little of the cold liquor along with it; then add more by degrees; and at length throw the portion so mix'd up, into the rest of the subject, and just stir them together. Then setting the whole over a gentle fire to boil, as soon as the hard scum or crust rises up, or just begins to break, remove the vessel from the fire, and with a slice take off the head; and run the remainder, whilst 'tis hot, through a flannel-bag; by which means

means the subject will be thoroughly depurated. For the white of the egg being mixed with the whole body of the liquor, and afterwards concreted or harden'd by the fire, it draws to, and intangles with it self, all the viscous, unctuous, and feculent matter it meets with, and can sustain; then mounting to the top, on account of its comparative levity, carries that up along with it, and there forms itself into a strong crust, which may be readily taken off, or separated by the strainer, so as to leave the subject perfectly fine and clear. The larger, the wider, and the lower the vessel is, which we make use of in this process, the better and the sooner it is perform'd; because the liquor will then exhale the faster; whereas, if it should be long in hand, the subject is very apt to receive some damage. This vessel, also, should, by all means, be of glazed earth, and not of copper or brass, tho' lin'd on the inside; for such vessels will be corroded by any decoction, or juice of a vegetable that is at all acid; and thence the subject will gain a vomitive quality, as I have frequently experienced.

3. The *robs*, *defruta*, *gellies* and *extracts*, prepared after this manner, *The nature of the productions.* are all capable of dissolving in water, and may be kept for a very long time unaltered in their natures and virtues; provided the moist air is not suffer'd to get at them. They all perfectly retain the taste and smell of the plant, as it was left in good measure deprived of both in our first process, by the exhalation of its odoriferous water; and consequently, these preparations must contain only those virtues of their respective subjects, which neither reside in the native spirit, nor in their solid, earthy, or feculent part. *Decoctions* and *extracts* differ only in point of consistence, or as to the proportion of their aqueous parts; being both of them a kind of saponaceous bodies, consisting of oil, salt, and water. It seems impossible to obtain a decoction that shall be purely saline, without any mixture of oil, which, in some measure, will always remain in the extract; because the degree of fire, made use of in that operation, is unable totally to expel it. But this is to be understood of that gross, or fixed oil of vegetables, which they yield by long decoction; and not of the volatile or essential kind, that is gained from them by distillation. And hence we see the reason why all extracts are inflammable.

4. The medicinal uses and virtues of these preparations are exceeding *Their medicinal virtues and uses.* great. For the decoctions or juices of plants may, by this means, be long preserved perfect and entire, without suffering any fermentation, or sustaining any greater loss than that of their more volatile, aqueous, or superfluous parts; so that at any time we may, by letting them down with as much warm water as they lost in the exhalation, obtain the natural juices of vegetables in great perfection, capable of being applied to medicinal purposes, with all the advantages that would attend them, if they were fresh express'd, and in their proper season. All the specific, or peculiar virtues of plants reside in their juices.

Processes upon Vegetables.

or that part which is soluble by the heat of boiling water. The remaining parts are merely vascular, or composed of solid terrestrial matter, incapable of receiving any change in the human body, or of communicating any virtues to it; proving the same in all kinds of vegetable subjects. Hence the several preparations afforded us by our present process, being freed from this terrestrial and inactive part, as well as from the aqueous, they are, *ceteris paribus*, more efficacious than the plants themselves, or their juices. And thus by boiling up the juice of quinces, for instance, to a due consistence, we may always have in readiness a medicine of great virtues, in cases of vomiting or looseness. And by such a contrivance, as this, it was that the antients obtained their portable wines. They took any quantity of must, or the fresh expressed juice of ripe grapes, and boiled it up, over a gentle fire, to an extract; which, when cold, they could carry with them on a journey; and so at any time, by diluting it with warm water, prepare a vinous beverage for their refreshment*. After the same manner, we may furnish our selves with portable medicines, fit to carry with us in a voyage to any part of the world; and capable of being used to as great advantage, as if the simples, we wanted, grew upon the sea. Thus, for instance, the extract of tormentil-root might immediately be brought back to a decoction, if an astringent liquor was required; and the rob of currants be diluted with water, if we wanted a drink of a refrigerating nature. But we are to observe, that to gain these preparations in their greatest perfection, the subjects should not be such as have been dry, or long gathered, but fresh, and in their full perfection; for, as we before observed, when plants are entirely deprived of their juices, no specific or medicinal virtues remain behind in their vessels or carcasses; but all of them would then act in the body after the same manner; or, to speak strictly, they would none of them act at all. An effete, worn-out and exiccated poisonous plant might as safely be taken into the body, as any of those reputed the most innocent.

The subjects best fitted for this process.

5. The vegetables best suited to undergo this process, or to afford their robs, defruta, gellies and extracts, for medicinal uses, are all of the fix'd or astringent kind; such as we set down in the catalogue under the second process. But those of the aromatic tribe, or such as stand in the catalogue of the first process, are very unfit to be treated in the same manner; because their virtues consisting in those parts which are of a tender and delicate nature, they would exhale, and be lost in the operation.

Introduction to the next.

6. The remains of this process, which are the same with those of the second, being gently dry'd, obstinately retain their pristine figure; tho'

* The portable-soup, lately introduced, is a production of this process applied to animal subjects. Any rich soup, or animal jelly, boiled up to the consistence of glew, will be fit for the pocket, and ready, upon occasion, to be presently dissolved, with a due proportion of hot water, into a mess; which might be very desirable upon a journey.

they

they are now insipid, inodorous, dusky in colour, devoid of all the native or specific virtues of the plant, and render'd perfectly sluggish and inactive. They have already suffer'd the utmost violence of the fire that could possibly act upon them thro' water; we are therefore, in the next place, to see what alterations will be produced by a naked fire, acting immediately thereon.

CHEMICAL HISTORY of vegetable SALTS.

PROCESS IV.

Exhibiting the manner of calcining, or reducing vegetables to white insipid ashes, by an example in the REMAINS of the second and third PROCESS.

1. **P**PLACE the carcass or skeleton of our rosemary, left by the preceding process, in a dry, and clean, iron pan, to be held over a clear fire till it begins to glow, or become red-hot; then the subject will presently smoke, smell strong, grow black, flame, shine, sparkle, and at length sink into white ashes, which still retain the external form of the original plant; but this in so loose and tender a manner, that the least touch will immediately destroy it. The process.

2. The fire, employ'd in this process, should be very clear, otherwise some saline part of the smoke might fall down into the subject, and impose upon the operator; by making him fancy it to be still sapid, tho', in reality, it was before deprived of all its taste by decoction, as it now is of all its odour, by the flame which consumed its oil. A caution to be observed in it.

3. There appears to be two kinds of smoke, viz. aqueous and oleaginous: the aqueous is that which exhaled in our first process, and appears constantly white; but the oleaginous is always black, and consists of the oily parts of the plant, which being at first driven out by the fire, escape its farther action, that wou'd, if they stay'd longer behind, convert them into flame. The fetid scent here observable, is caused by the oil of the subject, which is now so attenuated, and rarified by the action of the fire, and its parts put into such a motion, that it has a power to strike the nostrils more vigorously than when it remain'd fix'd and condensed in the plant. The same oil is the cause that the subject turns black before, or during the time, it flames; for beginning now to be extricated and set loose, it appears in a greater quantity upon the surface; soon after which, 'tis turn'd into smoke or flame; till being all consumed, at length it leaves the subject white. As long as any of this oil remains behind, the body continues to flame. Phænomena thereof.

Processes upon Vegetables.

*Nature of the
ashes obtained
by it.*

flame, glow, or sparkle; but that being gradually wasted, or gone off, in form of smoke or flame, the subject is at length left in the state of a shining or glowing coal, and presently after sinks down in ashes.

4. These ashes, which are as insipid as sand, and perfectly scentless, being first digested, and then boiled in water, communicate nothing that is saline thereto; and if the decoction is now strain'd, purify'd and exhal'd away, not one grain of salt will remain behind; only a pure and attenuated terrestrial matter, which, without great impropriety, might be called philosophical or virgin earth.

*Nature of the
subject.*

5. Hence we may learn what principles our subject remain'd possess'd of, after having been treated by the two preceding processes; or of what parts all vegetables consist, when they are deprived of all that was soluble in them, by the joint action of fire and water; viz. oil, and earth. For as nothing is inflammable but oil, 'tis certain that oil still remain'd in our subject, notwithstanding the long-continued action of the boiling water it sustained in the second process, and the large quantity of oil which was, from time to time, scumm'd off the decoction. That it remain'd possess'd of some quantity of oil, may likewise appear from the blackness observable in the coal, whereto the fire at first reduced it; for oil is the cause of this blackness, and resides in every body so long as it fumes, flames, and sparkles; but when the oil is all consumed, then the body loses its blackness, and falls into a white earth or ashes. And thus we see the reason why coals and soot are inflammable.

*The physical
and chemical
uses of the pro-
cesses.*

6. It appears probable, from this process, that elementary earth composes the vessels or solid parts of vegetables. It seems to follow, from some experiments made by Mr. Boyle, that pure water distilled ever so many times over, constantly leaves behind it a proportion of fine, white, virgin earth; from whence we may with some probability conclude, that the nutritious juices of vegetables, drawn into them in the form of water, deposite this terrestrial matter, or leave it behind them to form and constitute their solid parts: but this it seems unable of itself to do; and therefore requires the assistance of the oil we find in them, which adheres so tenaciously to it, that a great violence of fire is required to separate them; and seems therefore, to act as a glew in binding the parts of the pure, white earth together. This earth contains nothing peculiarly medicinal, and is found the same in all vegetable subjects. 'Tis incapable of being dissolved either by fire, air or water; and is, perhaps, the most perfect, pure and subtilized, that can any way be obtained by the art of chemistry. Even the focus of a large burning concave is unable to change or vitrify it, without an addition of sand; with which it presently runs into glass. Its being so fixed and unalterable in the fire, is the reason that the assay-masters employ it to compose their tests and cupels. Some also make use of it as a dentifrice; for it is a great absorbent, and gives a fine gloss or polish to the teeth.

7. The

7. The present process, compared with the foregoing, shews us that all the specific and distinguishing virtues of plants must necessarily reside in such parts, as are either dissolvable in water, or inflammable in the fire; and that the dryer or older any vegetables are, the more they lose of their native spirit, their salt and their oil; and the less their medicinal virtues. All plants by keeping lose of their weight. Their presiding spirit spontaneously exhales, which greatly takes off from their odour; their salts are diluted and attenuated by a moist air, as well as their oils, and rendered volatile, and carried off by a dry one. Thus any kind of wood, kept so long that it rots, falls of its own accord into ashes, without the help of calcination. And thus, as we before observed, the most poisonous, or the most medicinal simples may entirely lose their force and virtue by being kept too long. That horrid poison, the *Euphorbium* of *Mauritania*, will, with age, fall away into an indolent, innocent earth.

Hence also we see, in a nearer view, how it comes to pass that the vessels, or solid parts, of plants are neither destroyed by their own saline, aqueous, or oily juices, nor the external force that acts upon them: for their basis being of elementary earth, it can never be dissolved or changed by the action of the sun or water, nor by any of the parts or principles which enter the composition of their fluids. But if plants were wholly composed of saline and oily parts, they would soon be dissolved by the agents continually at work upon them.

It hence likewise appears, that there is no fixed salt in the solid parts of a vegetable: and the same holds true of animal substances. This may seem a paradox, tho' the truth of it is manifest from numberless experiments. But we need go no farther than the present process; the remaining ashes whereof are perfectly insipid as well as inodorous. 'Tis therefore a great mistake in those, who affirm that salt promiscuously resides in all the parts of vegetables; as well when they are dry and withered, as when they are fresh and green.

Lastly, we hence learn, that calcination renders vegetable subjects white, by depriving them of all their fetid oil, which it converts to smoke. And the same holds true also of animal substances. Thus in order to render the bones of a skeleton white, we endeavour to get out their oil, by laying them to steep in a *lixivium*, and successively exposing them to a warm dry air, which in time will carry off the oily parts, that make them appear of a yellow or dusky colour.

Processes upon Vegetables.

PROCESS V.

Exhibiting the manner of calcining vegetable substances into white, saline ashes ; by an EXAMPLE in the EXTRACT of the third PROCESS.

The process. 1. **T**AKE the black extract of our third process, lay it on a clean iron pan, and gradually dry it over a gentle, naked fire ; it will presently begin to smoke, smell strong, grow blacker, boil up like pitch, take fire, and burn out with a clear flame, shine, sparkle, and at length fall down into reddish ashes.

Nature of the ashes it affords. 2. These ashes, if farther urged by the fire, become white and inodorous, but very saline, or fiery upon the tongue, and contain but little earth. Being digested and boiled in clear water, then strain'd off and filtered, and the superfluous moisture evaporated, they yield a fiery salt, of a white or greyish colour. This salt differs in degrees of acrimony or sharpness, with the plant 'tis gained from. The ashes of all manner of vegetables are naturally saline, so far as we know: but the more pungent the taste and odour of any one is, the less of this salt it affords: or, in other words, the greater their quantity of volatile salt, the less is that of their fixed ; as evidently appears in horse-radish, and other pungent or antiscorbutick plants.

Corollaries from the process. 3. From hence it appears, that boiling water gets out two different parts from vegetables, which may afterwards be reduced together into an extract, viz ; (1.) an oil which will fume, grow fetid, exhale and burn away in an open fire, and is the cause of the blackness in the extract ; which grows the darker as its bulk is lessened by heat : and, (2.) a white fix'd salt, that contains a small proportion of earth ; and appears the same in all kinds of vegetables.

PROCESS VI.

Exhibiting the manner of calcining plants to white saline ashes, like those of the last, by an EXAMPLE in the REMAINS of the first PROCESS.

The process. 1. **T**HE remains of our first process, or any recent plant, being first gradually dry'd with a gentle heat, and then placed in a clean iron pan, and exposed to a clear, naked fire, will presently begin to smoke, smell fetid, shine, sparkle, flame, burn away, and at last fall down into ashes, that retain the

Processes upon Vegetables.

33

the form of the original plant, after the manner of the subject in our fourth process; only the smoke and flame in the present case are thicker and stronger.

2. These ashes are white, inodorous, saline, or of a fiery taste, and contain a considerable proportion of earth. When elixated, or boiled up in water, which is afterwards exhaled away to dryness, they leave a salt behind, perfectly like that of our fifth process; and an earth like that of the fourth. *Nature of the production.*

3. By comparing together the several processes which we have hitherto gone through it will appear, (1.) That all which the utmost force of fire, applied thro' water, can obtain from vegetables, is only their juices, and no part of their vessels; which always remain undestroyed after ever so long decoction. (2.) That vegetables by boiling yield a large proportion of combustible matter, or oil, to water. (3.) That the salt and oil of vegetables are naturally so united in them, that the greatest part of both may together be dissolved, or gained from them by boiling water: or that the salt and oil of plants are by nature formed into a kind of soap, that is readily soluble in water; which oil alone, without such a combination, wou'd not be. After the same manner as we find it in vegetables, so it is also in our selves: as long as the oil and salt are duly blended and kept together in our bodies, so long we are healthy; but if once this natural soap comes to be dissolved, or its texture destroyed, then both plants and animals languish, sicken and dye; unless proper remedies are speedily applied. (4.) That 'tis the oily part of vegetables which gives the dark colour to the decoctions, or extracts prepared for them; for the salt, being perfectly white, has no share in producing this colour. (5.) That the saline part of vegetables is more fixed than their oil. (6.) and lastly, That the specific or peculiar medicinal virtues of plants are owing to their native spirit or oil; not to their water, fix'd salt or earth, which appear to be the same in the whole class of vegetables. *Corollaries from the preceding processes.*

4. Having now seen what effects, or changes, are producible in vegetable subjects with the two grand instruments, water and fire, separate, or bined with air; and into what parts or principles they are resolvable by means thereof; what is the office and use of their earth; and how fixed salt is obtainable from them; we ought in the next place to examine what this saline matter is, which remains after calcination; and under what form, together with the oil, it originally præexisted in the subject. This is a piece of knowledge highly requisite in a chemist, to enable him the more clearly and distinctly to understand the changes brought upon such saline matter by the fire. A neglect in this particular might give occasion to a very erroneous opinion in chemistry, by suffering us to persuade our selves that salts exist in plants under the same form, and after the same manner, as they are produced, or made appear by the fire; which is directly opposite to the truth. *Introduction to the history of the essential salts of vegetables.*

Processes upon Vegetables:

truth. Thus an acid plant, as sorrel for instance, reduced to ashes, will afford an alkaline salt: but it would be a rash conclusion to say, that therefore sorrel is an alkaline plant; or that before the operation it contained an alkaline salt. All that cou'd fairly be concluded from such a process is this, that sorrel, treated in such a particular manner, afforded an alkaline salt.

P R O C E S S . VII.

*Exhibiting the manner of obtaining the native, or essential
SALTS of VEGETABLES, from their crude JUICES;
by an EXAMPLE in the JUICE of the plant SORREL.*

The process.

1. **T**AKE any plant whatsoever that is ripe, fresh gathered, in its perfection, green, and full of juice, as sorrel for instance; bruise it well in a marble mortar, and then, with a press, squeeze it strongly out; wash, or boil the pressings twice or thrice with a moderate quantity of fair water, and squeeze them out again. Then mix the several liquors together; let them stand a little in a quiet place to settle, and afterwards run them thro' a flannel-bag, that all the liquor may become clear. When this is done, boil it up in a glazed vessel, over a clear, gentle fire, to the consistence of a thin syrup; then pour it into an unglazed earthen pan, and upon the surface of the liquor let a proper quantity of clear oil be lodged, to defend it from the external air. In this state let the liquor remain in a cool cellar for the space of six or eight months; and during this time there will shoot to the sides of the vessel a large quantity of a darkish, saline, crusty matter, which is the native, or essential salt of sorrel; whilst an oily and terrestrial, or fat muddy part falls to the bottom; that being dry'd before the fire, and brought to a thick consistence, is combustible, and will burn away with a clear flame.

*Cautions to be
observed in it:*

2. This indeed is a tedious way of obtaining the native salt of a plant; but it is the shortest that I am acquainted with. The vessel, wherein the liquor is put to shoot, ought not to be of glass, tho' that wou'd have all the advantages of transparency, because its smoothness wou'd hinder the sticking of the salt to its sides; and so the operation be rendered still more tedious; but the juice easily insinuating it self into the pores of an unglazed earthen vessel, has a great advantage in shooting its saline spicula to the sides. And in this case, the want of transparency in the vessel may very well be supplied by that of the oil poured upon the surface of the liquor; which oil will give us the opportunity of observing the steps of the process, at the same time that by keeping out the air, it keeps the liquor from falling into fermentation, and prevents the vegetation and growth of mouldiness, or a mucilaginous substance

stance thereon; which would prove a very great impediment to the formation of the saline crystals; being it self the salt now rendered in some measure volatile.

4. This crusty matter, being freed from its liquor, separated from the sides of the vessel, immediately washed clean from its adhering mucilaginous faces, by repeated moderate affusions of warm water, and then gently dry'd, will exhibit the native salt of sorrel in the very manner wherein it præexisted in the plant; for this process has done no more than barely freed the salt from the inspissated juice; nothing being employed in it to cause a change but rest; which suffered the saline parts spontaneously to shoot and form themselves into crystals. And this is the only salt that chemistry affords us unaltered, or as nature produces it; in which case it never appears to be alkaline, from what plant soever it be obtained. And therefore it was well observed of *Helmont*, that the salt gain'd from vegetables by calcination, is greatly altered by the operation, and very different from the native or essential salt, or from what it naturally is in the composition of plants. *The manner of its action.*

5. These native salts differ in their nature and medicinal virtues with the plant to which they belonged; whence there comes to be a very great variety of them: but they may all be reduced and considered under three general tribes or species; viz. (1.) Those of the acid, astringent, or very austere vegetables, as of unripe fruits, &c. which perfectly resemble the tartar of wine. (2.) Those of the succulent or watery plants, which contain but very little oil; such as endive, succory, fumatory, house leek, &c. and these come nearly up to the nature of nitre; being a very pure kind of salt, and readily soluble in water; whence they are commonly called nitrous salts; and on account of their cooling virtue come to be employed in burning fevers, and other inflammatory diseases. (3.) and lastly, Those of the oily or viscid vegetables; as all of the aromatic and agglutinant kind. These afford it but in very small quantities; or scarce at all, till by due course of fermentation they have first thrown off their more viscous and oleaginous parts. For oil and viscid juices greatly obstruct the shooting of this salt into crystals; whence they run rather into faces and impurities, than any properly saline substance. But if once their oil be extracted from them, the remaining juice will readily enough afford such a salt. Thus, from the unfermented juice of an aromatic, odoriferous plant, such as mint, fennel, anise, &c. 'tis very difficult to gain the native salt. And hence it is that all fat wines, as canary, &c. scarce deposite any tartar at all; but such as are sharp, thin and poorer, throw it off in very great plenty. Thus from the juice of tamarinds, or our present subject, sorrel, this essential salt, is obtainable in great plenty; and from those of the watery plants, such as endive, brooklime, &c. which are not acid, in very large quantities; but then 'tis not so rich. We may therefore establish it as *The several species of essential salts.*

Processes upon Vegetables.

*How they shoot
in fermented
juices.*

a kind of rule, that the more oily any plant is, the less native salt it will afford by the treatment of this process; and *vice versa*.

6. After the same manner, when any fermented juices of succulent vegetables, as those of summer-fruits for instance, and particularly of tart grapes, are committed to vessels of wood; they in time throw off their native salt, otherwise called tartar, or wine-stone, to the sides thereof; and this always in greater plenty, as the fermented juice or wine is the more spiritless, acid, austere, and of a thick consistence, before it was put up. If the wine be very rich and oily, it will scarce deposite any tartar at all; for which reason it is never afforded by must. But in such rich and unctuous wines, a matter falls to the bottom of the cask, in the form of an oily sacculence. The purer or more transparent and colourless the wine, the finer and whiter will be the tartar. Hence that of *Rhenish* wine is usually preferred to all other kinds. But when the wine is red, its tartar also appears of the same colour. We shall hereafter make it appear that these essential salts, afforded either by the crude or fermented juices of vegetables, are not in themselves simple or uncompounded bodies, but resolvable or reducible into water, earth, spirit, different oils, and salts of all kinds, fixed and volatile, acid and unctuous; and from thence we shall learn in what form they exist in their respective subjects. For they will be found to contain an aqueous, and a viscous, acid, unctuous spirit; a large quantity of a very volatile penetrating oil, and a great proportion of one that is fixed and less penetrating; a considerable deal of the matter of a fixed alkaline salt; a very large proportion of earth; and to be of an acid, rather than an alkaline nature.

*Their medicinal
virtues.*

7. The medicinal virtues of these salts being the same with those of their respective plants, they may be more commodiously and advantageously exhibited than the simples themselves, or their juices; because a less dose of such a salt will contain the virtues of a much larger of the plant; and is also readier to be reduced into a proper form for taking. Thus an ounce of the essential salt, or tartar of tamarinds, for instance, dissolved in any proper vehicle, and drank, will prove as purgative as thrice the same quantity of the fruit.

PROCESS VIII.

Exhibiting the manner of preparing medicated SALTS from vegetables by calcination, after the manner of TACHENIUS; by an Example in recent Rosemary.

The process.

1. **P**UT rosemary, or any other green, recent, succulent plant, that has been gathered before it buds, or puts out its flowers, into an iron pan, close covered at the top with a plate of the same metal, and place it over live coals, that

that the subject may be gently scorched, without taking fire; or being made to flame, till the whole plant is reduced to a black body, or coal. (2.) Then the cover being taken off, the subject, thus torrefied, will begin to shine, sparkle and glow; during which time it must be continually stir'd about with an iron rod, till at length it ceases to give any more signs of ignition; or till it is reduced to white ashes. (3.) When these ashes cease to sparkle, and are grown perfectly white, put them into an iron pot, pour a proportionable quantity of rain-water upon them, and boil them together, over a naked fire, for the space of half an hour; or till the water has extracted all the saline taste from the ashes; which ought, in the mean time, to be frequently stir'd up from the bottom with an iron ladle. Then filtre the lixivium, or run it thro' a double flannel into another wide and open iron vessel or pan; and in this exhale away the superfluous moisture, over a strong naked fire. But when the remainder begins to grow thick, let it be kept carefully stirring; and thus at length it will become dry, and when removed from the fire, appear in the form of a grey or dark-coloured mass, which is the medicated salt of rosemary, prepared after the manner of Tachenius.

2. If this salt be now put into a clean iron crucible, covered to keep out the dust, &c. and committed to an open fire, 'twill flow like nitre; and if, after having remain'd for some time in this state, it be poured out upon a metalline plate, we shall have a saline mass farther purified than the former, and either of a whitish, or a brownish, a grey, or a lead-colour, capable of being cut into pieces of any figure. Farther continued.

3. This salt will be made still purer and finer by farther solutions in fresh water, and repeated filtration and exhalation; so that at length it might be brought into a fine transparent crystalline substance: but so much trouble is no ways requisite to fit it for medicinal uses.

4. The subjects designed to afford this salt in its greatest perfection, and to the best advantage, should abound but little in volatile salt, and be gathered in the leaf, before they put out their flowers; because at that time they most abound in salt: but after the spring is far advanced, and the flowers appear, they grow more oily, and lose a great deal of their saline part. And the more gently we proceed in torrefying them, the larger quantity of salt they will afford. 'Tis thus reducing the plant to a coal, in a close vessel, which stifles the fire, keeps in the smoke, and fixes the oil, that constitutes the manner used by Tachenius in the preparation of salts; which therefore go by his name, because he was the first who accurately described the process, in his *Hippocrates chemicus*: not that he was the original inventor; for they seem to have been more anciently known: and *Raymond Lully*, with many other chemists, were well acquainted with them, before the time of Tachenius. But if his method were not made use of, or if the plant were suffered to burn out in the open air, a great part of what is volatile in it would be lost to the salt; which, in that case, would become highly caustic or fiery: The cautions it requires.

Processes upon Vegetables.

fiery: but this we would here avoid. The design of our process is not to give us a corrosive salt, after the common method in which the trading chemists prepare their salt of wormwood, by setting fire thereto, and burning it till all its combustible parts are consumed in a crackling flame or blaze; for by this means they can never obtain a balsamic or saponaceous salt, which ought to contain a proportion of oil; and which by our method is kept in it; whence our salt is also termed *medicated*, on account of the great virtues which, by this treatment, it comes to have in medicine, as we shall see hereafter. A coal is nothing but a terrestrial vegetable matter, wherein there remains such a proportion of oil, as renders it black, and combustible; and may be prepared as well from linen cloth, as the loppings of a tree; for they would then differ only in regard of their bulk or substance, and not of their nature. And if the subject of our process should remain stifled, or close covered down in the torrefying vessel, over the fire, for the space of a whole year, yet, during all that time, it would continue in the state of a coal; but if after this, the external air be let in upon it, the oil, that was condensed and fixed in the torrefaction, will immediately be in great measure consumed, and the black body appear in the form of whitish ashes. When the fire is thus suffocated or stifled in the subject, the ashes, to which it is afterwards reduced, are of a redder colour than those obtained by means of an open fire; and the more it is suffocated, the redder these ashes will prove: which shews that in such a case the oil is more intimately mixed and united with the salt of the plant. And the greater this degree of redness is, the better are the salts, and the less alkaline or fiery. When the oil is thus united with the salt, and fixed in it by the fire, they together constitute a saponaceous body, which will readily flow with heat: whereas the salts, prepared by an open flame, requires the utmost degree of heat to run them. If the fire were not sufficiently stifled in the subject, the colour of its salt will be too white. But 'tis scarce possible to determine the colour of it beforehand; there are so many circumstances which may cause it to vary. If a little smoke should any way mix therewith, 'twould turn it of a blackish colour; and thus sometimes it appears white, bluish, grey, or lead-coloured; but 'tis always esteemed the best for being of a brown colour, easy of fusion, and not corrosive or fiery.

*Medicinal uses
of the prepara-
tion.*

5. The properties and medicinal virtues of these medicated salts, prepared after the manner of our present process, are very considerable. For, not being of a caustic or fiery nature, but of a proper saline taste, they come nearly up to the native salts of vegetables; as containing a large proportion of native oil, by means whereof they are the most mild and gentle of all the salts obtained from plants by incineration or calcination. They may also, on account of their virtues and saline nature, be used instead of common or sea-salt. Thus *Pliny* tells us of
peo-

people, that live about the *Alps*, who, wanting the convenience of sea-salt, prepare one for themselves by burning the plants that the place affords, which serves them very well for their ordinary uses. They are not of a very alkaline nature; or greatly opposite to acids, of which they absorb or drink in but little. They relax or grow soft in the air, but can scarce be made to run therein; tho' they dissolve in water, and easily flow in the fire; by which last property they are distinguished from fixed alkaline salts. They readily mix with every fluid of the human body, except the oily, with which they unite more slowly. They with great ease enter, and with full force, into the blood, and the lymph; but it may be questioned whether they can ever insinuate themselves into the fine canals of the nerves, upon account of the grossness of their substance; for their *lixivium* will not pass thro' a large heap of sand; and we can find little or no taste in the spinal marrow, except in those parts of it where the blood appears to run. And this may be the reason why in nervous cases the art of medicine has no greater effect. They are capable of resolving the coagulated humors of the human body; and greatly attenuate the juices of it. They will not, however, dissolve the stone in the bladder; nor presently wear away the gouty matter that is once lodged and fixed in the joints. By their acrimony, they gently stimulate the solids, or vessels of the human body, without corroding them; and consequently they must necessarily prove deobstruent or aperitive; since they act as well by stimulating the solids, as by diluting and dissolving the fluids; in which operation they are greatly assisted by their gravity. They forward and promote both the natural secretions and excretions of the body: for whatever stimulates the solids, dilutes the fluids, or dissolves the coagulated juices, must necessarily solicit and promote all manner of separation and evacuation, especially in the blood and lymph. And consequently they must be sudorific, diuretic and cathartic; and act as well in the *primæ viæ*, as after having passed the lacteals. Whatever thins the blood, dissolves the other juices, and opens the mouths of the subcutaneous vessels, so that the fluids plentifully derived thither may there pass off, is called a sudorific. Whatever does the same in respect to the glands of the kidneys, we term a diuretic: and that a cathartic, which after a similar manner, renders the fæces of the intestines moveable, by lubricating the passages, or deriving proper moisture plentifully into them, from the secretory vessels, with which they are lined; when the same stimulus, continuing to act, will solicit their ejection by the muscles, whose office it is. Consequently, these salts must be serviceable in chronical diseases; where the *vis vitæ* is decayed, and a *vis inertia* reigns. All the physicians, from the days of *Hippocrates* down to the present time, agree in this, that chronical diseases proceed from a glutinous matter a viscidty, or a lentor in the vessels, which retards the freedom of their action; and if this be actually the case, a bet-

ter

Processes upon Vegetables.

ter medicine could scarce be contrived for the removal of them, than our medicated salts. Dr. Sydenham, tho' an enemy to chemistry, was beholden to it for the salt of our process; which he obtained by ordering the ashes to be boiled in wine, and the strained liquor to be drank in cases of the dropsy. But we are to observe, that salts should by no means be exhibited where the constitution is already saline, or where the solids are too weak to sustain their action.

There are various methods of administering these medicated salts, which may be differently suited, according to the design or intention of the physician. But in general, they ought to be taken in a morning, upon an empty stomach, in the quantity of five grains up to that of a dram, or more, as the constitution may require, for a dose; to be dissolved in a proper proportion of fair water, for a draught. But when 'tis design'd to act as a cathartic, the patient ought over-night to swallow a few grains of aloes, made up into a pill; or half a scruple of the *Pilula Ruffi*; that the medicine, which is indifferent of itself, and undetermined to any particular way, may be directed to the *prima via*, and exert its virtue upon them. To forward the operation, the person may, without danger, take a walk in the open air, so that he does not fall into a sweat; for this is a thing that works with great gentleness, and gives no disturbance to the body.

When we would have our salt work by urine, no purgative should be taken on the night preceding; but some warmish liquor, such as tea, whey, or the like, ought to be drank off freely, during the operation, in the morning. And by observing this direction, 'tis incredible what a quantity of urine will be discharged. For the same purpose, likewise, a light lixivium might be made, by dissolving a small proportion of our medicated salt in a large one of clean rain-water; by which means there will be instantly prepared an artificial water of greater virtues than those of the diuretic springs, or even the *Spaw* itself, and capable of being drank in the same manner: the patient walking about in the cool air, which by contracting the excretory vessels of the skin, will determine the fluids the more to the kidneys.

When it is intended to cause a diaphoresis, 'tis proper to take it in bed, and to drink a large draught or two of some hot liquor upon it, such as sack-whey, sage-tea, a decoction of sassafras, or the like; and by this means it will admirably break away and dissolve all manner of concretions or coagulations, form'd in the blood-vessels or lymphatics. This salt also is a very powerful medicine in stubborn fevers, or tertian agues. The quantity of three drams thereof being dissolved in water, and taken at several times, in the interval of two paroxysms will seldom fail to cure an obstinate tertian, or quartan ague. For by its penetrating and active virtue, it breaks away all ob-

obstructions in the capillaries, and opens a passage for the impacted matter to escape at, through the glands of the skin; whereby all the febrile lentor is at length dissolved, and carried clean out of the body. But, then we must be careful to what persons we use our remedy; and be well assur'd they are able to undergo the operation thereof; for it might prove of very ill consequence to give it to such as are phthysical, hectic, or labour under any inflammatory disorder. Lastly, our salt is an inestimable medicine in all hypochondriacal and hysterical cases. 'Tis surprizing how well it succeeds with valetudinarians, or patients of a sedentary, studious life, who are generally costive, and apt to be left more so by the common cathartics, after they have once perform'd their office; whence, by a frequent repetition of them, this sort of patients are commonly made worse than they were before. But our medicated salts are so friendly to the body, and so gently discharge the intestines of their load, as to leave the belly soluble, and the patient in an easy and composed state.

P R O C E S S IX.

Exhibiting the manner of preparing the MEDICATED SALT of the eighth PROCESS, from DRY PLANTS; by an example in dried ROSEMARY.

1. **I**F any green, ripe, succulent plant, be gathered in its proper season, when the weather is fair, and carefully dry'd in the shade, so as not to lose all the odoriferous water of our first process, and, as soon as it is dry, be treated in the very same manner with the subject of the eighth process; it will exhibit altogether the same phenomena, and afford the same kind of salt, only the subject in this case being dry'd or deprived of its superfluous moisture, before 'tis committed to the operation, the torrefaction will here be sooner perform'd.

2. Hence we are furnish'd with a way of preparing the medicated salt of Tachenius, with more expedition, ease, and cheapness, without at all impairing its virtues.

Processes upon Vegetables.

PROCESS X.

Exhibiting the vulgar method of preparing fixed salts, from vegetables, by calcination, after the manner of the trading Chemists; by an Example in the dry'd stalks of Rosemary.

The process.

1. **L**AY any dried vegetable, or part thereof, as here the stalks of rosemary, upon a clean open hearth; and with the flame of a taper, or the like, applied to the bottom of the subject set fire thereto, and it will immediately begin to smoke, crackle, or hiss, flame out, or blaze, and at length fall down into whitish ashes; which are to be stirr'd about with a stick, till they perfectly cease to sparkle. (2.) These ashes, thus kept moving about, till not the least spark of fire appears among them, will become very white and saline; and being treated after the manner of those in our eighth process, will afford a much whiter salt than that of Tachenius, at the same time that it is vastly more caustic, or fiery, more opposite to acids, specifically lighter, and approaching nearer to the nature of fix'd alkali.

Phænomena observed therein.

2. In this operation we may observe, (1.) That in those parts where the subject flamed, there was no smoke to be seen. (2.) That the smoke at first was light and small, but increasing by degrees, grew thicker and blacker, and then vanish'd in a crackling flame. (3.) That the apex and sides of the whole flame were covered and surrounded with a smoky cloud. (4.) That in those parts where the smoke was thickest, the flame broke out the soonest. (5.) That all the remaining matter which had any blackness in it, continued to burn; but as soon as ever the blackness disappear'd, the same matter would no longer be ignited. (6.) And, lastly, that if these ashes, during the time they were black and sparkled, were put into a close iron vessel, every way defended from the air, they would still remain ignited so long as any black speck was to be seen among them.

How performable to best advantage.

3. In order to obtain this salt in large quantities, to the best advantage, or the greatest profit, 'tis the method, when the first parcel of the vegetable subject is reduced to ashes, to lay more of the same kind upon them, and repeat the operation till the desired quantity of ashes is obtained: all which must be kept continually stirring about, so long as any apparent fire remains in them, or till they are become perfectly white. For as long as any plant either sparkles, or retains a blackness in calcination, its ashes will not dissolve to advantage by being boiled in water, or give out their salt thereto. It would be an idle attempt to go about obtaining any quantity of fix'd salt from black ashes, or coals; wherein it is too much lock'd up by the oil, which is the cause of their blackness, to be extracted with water. But when once this oil is entirely driven off by a proper ignition, the salt will easily dissolve away from the ashes.

4. We

Processes upon Vegetables.

43

4. We need not be curious in the choice of our subjects for this process, if they are but gathered at the season when they most abound in salt; since the vilest vegetables may afford the salt we want from them, as well as the noblest. Thus it might as well have been prepared from bean-stalks, the cuttings of the vine, the loppings of the willow, the plant kali, hay, straw, &c. without any remarkable difference from that afforded us by our rosemary. Nay, the mixture of a number of plants together will yield it, so as scarce to be distinguished from the salt of any one particular plant; provided the requisite care is taken in the preparation. From whence we have a remarkable instance of the power of fire or flame, to destroy the specific medicinal virtues of all manner of vegetable substances. I will not, however, be positive that there absolutely is no difference at all between such ashes, or such salts of plants; but if there be any, 'tis too small to be discovered by the joint assistance of all our senses together.

*The conclusions
to be drawn
from it.*

5. We have now seen, that there are two different ways of obtaining salts from vegetables; the one without the assistance of fire, and the other with it. (1.) Those obtained without the help of fire, shoot, of themselves, from vegetable juices, both before and after they have undergone fermentation; and these are called the native or essential salts of plants. (2.) By the assistance of fire, we obtain two other different salts from vegetables; *viz.* by calcining them, after the manner of *Tachenius*, and stifling the flame; and by burning them, or suffering them to flame away in the open air. The method of *Tachenius* affords us a salt in greater plenty than the other, on account of its keeping in the oil of the plant, and in some measure mixing it with the fixed salt thereof; whereby the specific gravity of it is increased to almost the double of what it is in the fixed salts prepared after the manner of the shops. Whence we are given to see the foundation for a difference between the two, as to their obvious properties and medicinal virtues*.

*The difference
between this
production and
the former.*

P R O C E S S X I.

Exhibiting the manner of producing Fix'd Alkali, or a most corrosive, fiery, alkaline salt, from vegetables; by an example in the ashes of the tenth PROCESS.

1. **P**UT the pure white ashes of our last process into a Hassian crucible, and commit it to a strong, open fire, for the space of a few hours, so that the subject may be kept continually fluid, without vitrifying or

The process.

* One of the principal medicinal virtues of the salt of this process is, that when mixed with a due proportion of the juice of lemons, as in the quantity of a dram with three ounces of the juice, to stop any violent fits of

vomiting; which it does in a surprizing manner. The salt of wormwood, indeed, is commonly prescribed for this purpose; but the chemists well know, that a cheaper preparation will serve the turn.

Processes upon Vegetables.

running into glass. (2.) Then the crucible being removed from the fire, and suffered to cool, dissolve the ashes in water, filter the solution, exhale it away in an open iron vessel, with a strong heat, and keep it stirring about with an iron rod, or ladle, towards the end of the operation, till the remaining matter coagulates into a very dry and white mass. (3.) Put this mass into a very strong crucible, cover it close, and place it in a vehement fire, that the matter may run for two or three hours, upon which it will gradually turn of a blue or green colour; then pour it out into a metalline dish, and it is the fixed alkali, or lixivious fiery salt we wanted.

Cautions to be
observ'd in it.

2. Great care must be had in preparing this salt, to pour it out of the crucible, into a pan that is perfectly dry; for should the least drop of moisture be lodged therein, it would instantly break the vessel into a thousand pieces, and with a violent noise throw them all around, with such a force, as wou'd be highly dangerous, or prejudicial to the lookers on. It might be more convenient, in some cases, to pour it upon a dry metalline plate, rather than a vessel, on account of the difficulty there would be to get it out; for unless, from its being first emptied out of the crucible, you keep it continually stirring to break its parts, it will presently harden into a solid lump, and adhere so strongly to the sides of the receiving vessel, as not easily to be loosen'd and freed from them. And if it be suffer'd to remain in this state for any time, the air will run it into a liquor; for it is highly attractive of moisture, and cannot possibly be kept dry in any vessel, tho' of stone or metal, but one of glass; which also must be very closely stopp'd, to prevent its running. Nay, if it be kept in a glass, close stopp'd with a cork, and tied over with a bladder, it will in time relent.

Nature of the
preparation.

3. This salt is always the more corrosive, alkaline and fiery, the longer it was kept in fusion, and the greater the degree of fire it sustain'd; provided it was not vitrified thereby. During its stay herein, it continually changes from one colour to another, in the order of grey or brownish, white, blue, green, dusky, reddish, or marble-colour'd; according to which several colours, its degrees of strength are gradually heightened, till at length it becomes so highly corrosive, that being slightly applied to the body of any animal, it immediately eats away the flesh to the very bone; whence it seems to be nothing but a parcel of concentrated fire. There was a dismal instance, mentioned by *Tachenius*, of this corrosive power of our salt at *Venice*; where a man, happening to fall into a large boiling cauldron of its lixivium, had all the flesh taken off from his bones in an instant; so that the people, who immediately came to his assistance, drew out a perfect skeleton instead of a man.

Whence obtain-
able.

4. All manner of vegetable substances will afford this corrosive salt. Thus it may be prepared from their juices, decoctions, robs, *defruta*,
ex-

extracts, essential salts, obtained either before or after fermentation, the medicated salt of *Tachenius*, and the several parts of plants. But different subjects yield it in different quantities; and require different lengths of time, and different degrees of fire to bring it to the requisite corrosiveness or acrimony. No subject affords it sooner, in greater plenty, or of greater strength than tartar, and the plant *kali*. The cuttings of the vine will also yield it to advantage. The *Russia* pot-ashes are prepared from the loppings of trees, after the same manner with those in the second step of our present process; and by the same means reduced to a dry mass, that breaks into lumps, which is the more esteemed for appearing of a blue or greenish colour; tho' they generally appear of a grey one. These caustic or lixivious salts, were heretofore prepared in *Egypt* only, from the thorny plant *kali*, which there grew in great plenty upon the sandy soil, near the sea-shore: and hence all fixed salts probably came to be called *alkalies*. The lixivium, or salt of this plant, they called by the *Arabic* name *Sotha*; and hence, at this day, the soap-boilers among us call the salt prepared in the same manner, *Soda*.

5. The fire employed in our present process, ought to be violent, *And in what manner.* or else the operation would proceed so slowly, as to require several days to finish it; but if the heat were raised to too great a degree, the subject would be vitrified, and so our labour be lost. For some proportion of earth will for ever remain in the salt, and render it liable to be converted into glass; which is nothing else but a mixture of fixed alkaline salt, and earth or sand run together by a very violent fire; in which operation the salt corrodes or dissolves the earth into a substance that is at first dark, but by the farther action of the fire, becomes transparent. And thus the ashes of all plants are capable of being run into glass by a strong heat, as *Zoar*, an antient commentator upon the books of *Moses*, has long ago observed.

6. The salt prepared after the manner of this process, is endowed *Its properties.* with the following properties. (1.) A fiery taste; for if the smallest particle of it be applied to the tongue, 'twill prove extremely pungent, acid, and corrosive, burn into it like a fire-coal, and cause an ulcer that requires some days time to heal again. (2.) No manner of smell; only when mixed with the saliva of the mouth, and held near the nostrils, it affords an urinous scent. But this does not seem to proceed from the fixed alkali, so much as from the saliva, which contains urinous salts. For 'tis the nature of our preparation to unite itself with all other salts, so as to suffer them to appear in their own form, and with their peculiar properties. (3.) A caustic virtue; whereby it will eat away and consume all the soft parts of a human body; and in time corrode even the bones themselves. (4.) An hostility to acids; with all which it makes a conflict, boils up, and destroys or changes.

Processes upon Vegetables.

changes their nature. (5.) A power of dissolving the various con-
 creted juices of the body, except those of a stony nature. (6.) A facul-
 ty of uniting with all manner of gummy, resinous, and sulphu-
 reous bodies. (7.) A disposition to mix with all oily or unctuous bo-
 dies, so as to compose a soap: by which property it is that a lixivium
 of it readily gets the oil out of animal bones, and leaves them pure and
 white. Whence we have a method of preparing beautiful skeletons.
 (8.) A power of running all terrestrial substances into glass, by means of
 a strong fire. (9.) It relents in the air, and attracts a quantity of wa-
 ter out of it; which, tho' strongly detained by it, may again be drawn
 out by distillation. It also appears to drink in some acid salts from the
 air; because by frequently running *per deliquium*, therein it becomes a
 salt of a different kind. (10.) It is fixed in the fire. (11.) It compounds
 into a saline form with acids, which is determinable by them, so as to
 afford a variety of salts. Thus if it be put into spirit of nitre, it will
 successively attract the nitre, and it self become salt-petre. So if vine-
 gar be poured upon it, the fluid will be converted into insipid water;
 and its acid parts remain absorbed by the fix'd salt. But in some
 mixtures it may afford neutral salts, of a middle nature between acid
 and alkali. In the spirit of alum it will turn into alum; and in the spi-
 rit sea-salt, it will become sea-salt it self. And this rule appears to be
 universal. (12.) It penetrates all the vessels wherein 'tis kept in fusion;
 especially those that are made of earth. And sometimes it will cor-
 rode the brass or iron cap, or stopple, of the glass which contains it, so
 that it may be crumbled between the fingers. (13.) It precipitates a
 red powder from a solution of corrosive sublimate in water; and turns
 the juices of violets, roses, turnsol, &c. of a green colour. (14.) When
 mix'd with thrice its quantity of chalk, bone-ashes, potters earth, or the
 like, and exposed to a violent fire, it cannot be brought to flow, but
 becomes volatile, and flies off into the air. (15.) Lastly, 'Tis a pro-
 duction of art, not of nature; and never to be obtained without the as-
 sistance of fire. * All true fixed alkaline salts constantly possess these
 properties, and may indifferently be obtained from all manner of ve-
 getables, without retaining any thing of the specific difference obser-
 vable between them; as Doctor *Stare* in the *Philosophical Transactions* of
 the royal society at *London*, has fully shewn. *Tachenius*, indeed, was of a
 contrary opinion. He supposed that all fixed salts constantly retained
 some of the nature and specific virtues of the particular plant that
 afforded them. And this may be true of the salts prepared from
 ashes which were not thoroughly calcined; and therefore have some part
 of the oil of the vegetable remaining in them; which may well cause a
 specific difference. But when such ashes remain long ignited, and are
 become perfectly white and free from oil, whatever was specific or pecu-
 liar in the plant, and depended upon its oil, is wholly destroyed thereby.

* The *Egyptian* nitre appears to be a natural fix'd alkali.

7. The medicinal virtues of our fixed alkali are these. (1.) It destroys ^{its medicinal virtues and uses.} all manner of acids in the human body, wherever it meets with them. Oil of tartar will take off the violent acidity of oil of vitriol; and much more easily mortify the milder acids which lodge in the human body. (2.) It makes an ebullition or effervescence with acids; and after it is saturated, forms itself with them into a third kind of salt, of a neutral nature, and harmless or beneficial to the body. During this effervescence it moves it self every way from its centre of magnitude; and by this means raises the spirits that were oppressed by a suffocating acid. Thus in hysseric cases proceeding from an acid cause, this salt is of wonderful efficacy. It attenuates and resolves whatever was coagulated by acids; and breaks the texture of any glutinous matter. It disposes the oily parts of the fluids to unite with the aqueous, and blends them together after the nature of soap. It dissolves and breaks away all manner of coagulations formed by the bile, lymph, blood and serum, or any compositions of them. 'Tis endowed with a great stimulating virtue or acrimony, whereby it excites the nerves and fibres of the body, so as to make them perform their respective offices with briskness and vigor; whence it will prove diuretic, sudorific and purgative. And consequently it must be a powerful medicine in such diseases, as proceed from a lentor, or any glutinous, unctuous, acid matter lodged in particular parts of the body; such as the dropsy, where the liver and viscera are sound, the jaundice, the scurvy from an acid cause, the gout, &c. Thus in that species of the gout, which is caused by a predominating acid, a few drops of the oil of tartar *per deliquium*, taken once a week, in a glass of wine, is an excellent medicine; but must never be used when the body already abounds with alkalies. And in all hot and inflammatory constitutions and diseases, all colliquative or malignant fevers, the small-pox, the measles, all pestilential cases, and wherever the body tends to a state of alkaline corruption; when the blood is in too great motion; where the solids and fluids are too much dissolved and melted down by a long continuance of chronical diseases; where there are signs of a predominating volatile alkali; where the bile is too much diluted and attenuated; and where the lungs are ulcerated, &c. in all these cases our salt must be avoided as poison; because it would here increase the disease, and might easily prove mortal. This salt may be safely used internally, after the same manner as was prescribed in administering the medicated salt of *Tachenius*: but the dose of this ought not to exceed at hird of that; and requires to be diluted with a larger proportion of water. In cases of chirurgery, our caustic salt is of very great use; for it excellently cleanses and deterges foul, sanious or phagedenic ulcers; instantly puts a stop to gangrenes and mortifications; takes down fungous flesh, and wears away all manner of excrescences, as warts, the callous lips of wounds, &c. It likewise serves to make issues, and to open tumors, in order to

dis-

Processes upon Vegetables.

discharge the matter of them: but it cannot be well applied in nervous parts; because of the great pain it wou'd in that case excite. To stop a gangrene, we need only draw a line with it about the affected part, which will immediately cause an eschar, that, like a bar, prevents the mischief from spreading farther: or if it is come to a mortification, the part shou'd first be scarified, till the sound flesh appears; and then some of the lixivium of our salt, being applied thereto, will induce an eschar, which may be afterwards separated in the common manner. Foul ulcers need only be washed with a lixivium of it; and fungous flesh, the callous lips of wounds, warts, &c. be gently touched with the salt it self in substance. But to open tumors, or make an issue, a small portion of it ought, for some time, to be kept upon the part, with a proper bandage. Lastly, this salt will afford us an admirable, safe and innocent cosmetic, to cleanse the skin and take away the freckles, spots, or breakings-out that are apt to deform it; as M. Homberg, in the *French Memoirs* elegantly informs us. To which purpose we need do no more than dissolve a little of it in a considerable proportion of water, and frequently use the liquor as a wash.

PROCESS XII.

Exhibiting the manner of purifying the FIX'D SALT of the eleventh PROCESS, by running it per deliquium.

The process.

1. **P** PLACE the fiery alkaline salt of the preceding process in a crucible of earth or iron, and commit it to a proper charcoal fire, that the salt may flow, for the space of four or five hours; or till it becomes of a reddish colour and vehemently caustic. (2.) Dissolve this salt in water, and let it stand in a cool place till it deposits a saline matter, in the form of crystals, of a bitter taste, tho' neither acid nor alkaline, but something sui generis, at the bottom of the containing vessel; and which is afterwards with difficulty soluble in water. If now the liquor that floats above this matter be exhaled away, it will leave a purer salt behind it; which being again committed to the crucible, and placed in the former degree of fire, will become a most violently corrosive and fiery salt. (3.) Let this salt, thus prepared, be exposed in a wide and open glass vessel, to the air of a cool cellar, and it will swell, relent, grow soft, and, at length, in part dissolve into a thick and heavy fluid; which is to be committed to the filtre. The matter which remains behind undissolved, must be exposed to the air again, till 'tis fit to pass the filtre; and the same operation being repeated occasionally, the whole quantity will at length be resolved into a limpid liquor, and a portion of terrestrial

terrestrial matter or *faeces*, incapable of any further solution. The limpid liquor separated by the filter, is called by the name of an alkaline oil, or oil of tartar, made per deliquium.

2. If this limpid liquor be suffered to stand for any considerable time *Continued.* in a quiet place, saline crystals will form themselves at the bottom of the vessel, which cannot so easily be produced by any other method. And if the same transparent liquor, prepared per deliquium, be again exhaled to dryness, dissolved in the air, and fused in the fire, for a number of times successively; it will at the last go off wholly into the air; leaving only a small proportion of earth behind it.

3. The vessel wherein the salt is set to run, should be of glass, or glazed earth at least, because 'tis apt to corrode those of any other matter; *Cautions and observations relating to it,* and it should be wide and open that the air may freely come at the subject to dissolve it. The liquor, that is thus made to flow by the moisture of the air, ought rather to be decanted off, pure and limpid, from the remaining part of the subject, that is not hitherto dissolved, than be committed to a filter of paper, to fine and purify it; because, as paper is made of linen rags, beat to a pulp, which is fastened or held together by starch, the liquor is apt in passing thro' it to dissolve this glutinous substance, whereby the salt becomes impure, and afterwards deposits the greater quantity of *faeces* when it comes to be run afresh. The liquor, thus prepared, seems to have obtained the name of oil, upon account of the unctuous state it appears in when first 'tis run, or before 'tis decanted off from its *faeces*, or purified by the filter: not that it really has the properties of an oil; for it is not inflammable, but if thrown into the fire will put it out. The *faeces* which remain after the operation is finished, are merely terrestrial, and commonly appear of a black colour; notwithstanding the liquor which deposits them is pellucid, and the salt, at length, so white. The process of preparing this *lixivium per deliquium*, is called philosophical filtration, on account of the impossibility of further resolving the terrestrial *faeces* it leaves behind it, or bringing the salt to a greater degree of purity. The specific gravity of our oil is very considerable; it being the heaviest fluid we know, excepting quick-silver and oil of vitriol; and making an excellent menstruum, and as pure and strong a liquid alkali or *lixivium*, as chemistry can afford us.

4. If in order to prepare the salt of the eleventh process for the business of this, we should add to it thrice its own quantity of any matter that would prevent its fluxing, as tobacco-pipe-clay, chalk, or rather bone-ashes, and thus expose them to the fire after the former manner; we should obtain a very corrosive salt, and fit for our purpose. But then, tho' the salt might be rendered sharper by this means, because more fire would be fixed in it during the operation; yet a large quantity of the salt itself must necessarily be lost, because being now rendered volatile, it would fly off into the air. To hinder the flowing of a subject, promotes the action of the fire upon it; which cannot sustain so great a violence,

Processes upon Vegetables.

olence, when kept in a perpetual flux. Thus if a quantity of sea-salt were kept in fusion, for the space of twelve hours, it would suffer no change by the action of the fire during that time; but if thrice its own quantity of bone-ashes be thrown along with it into the crucible, this would keep it from fusing; so that by the action of the fire, it would, in the same time, be render'd so sharp, as afterwards to afford a corrosive spirit; tho' a large part thereof must necessarily have flown away in the operation.

P R O C E S S XIII.

Exhibiting the method of preparing the common caustic, or the strongest and most fiery of FIX'D ALKALINE SALTS, with quick-lime, for chirurgical uses.

The process.

TAKE of the fine dry quick-lime of Liege one part, strong Russia pot-ashes two parts, place the ashes upon the lime, and expose them together, in an iron vessel, to the air, till the lime falls to pieces, or appears to be flaked; then pour upon them four times the whole quantity of hot water, and boil them together for some hours; afterwards decant the clear liquor, and run it hot thro' a filtre of linen, several times doubled, and exhale it over a strong, open fire, till it comes to a dry mass; which being put into an iron crucible, is to be committed to a gentle heat, and there to be kept for some hours, during which the matter will flow like wax; then pour it out upon a dry, copper plate, and presently, before it grows too cold, cut into oblong pieces of a convenient size; which are immediately to be put up into a dry, warm, glass vessel, and secured from the air: and thus we shall obtain a proper caustic salt for chirurgical uses.

Phænomena observed therein,

2. The pot-ashes being here made to relent, and dissolve, by the moisture of the air, this serves to flake, or extinguish the quick-lime; from whence we have a kind of dry effervescence, in which the fire of the lime being joined with that of the ashes, they together afford so strong a *lixivium* with water, that if the finger were to be put into it whilst 'tis boiling, it would instantly eat it away to the bone. This *lixivium* also will suddenly destroy paper; but linen is better able to sustain the force of it, which therefore is here made choice of for the filtre, or strainer; for it would presently dissolve any woollen substance to a jelly. 'Tis the property of the salt thus prepared to flow in a gentle fire; whereas the alkaline salts, prepared in the vulgar method, require a vehement one to flux them. There is scarce any thing which chemists have more eagerly sought after, as particularly *Paracelsus*, and *J. Hollandus*, than to incerate fix'd alkalies, as they term it; that is to reduce them, as it were, into the state and form of wax: which problem is now solved by means of the present process. For after our salt is poured

poured out upon the metalline plate, it may, before it grows too cold, be readily cut and divided with a knife into parts of any figure, which to fit for chirurgical uses is commonly cylindrical; for it will retain any figure after it is thoroughly cool'd. But when once it is thoroughly cold, it becomes too hard to be managed at this easy rate. For after it has continued in fusion for some hours over the fire, it commonly appears of a green, ash, or dark brown, which last is the colour that denotes it to be most highly sharp, corrosive and fiery. This salt easily relents in the air, and runs into a reddish liquor, as it were of a fire-colour, tho' that of the matter it self was contrary thereto. This liquor, if permitted to stand at rest for some time, will deposite a proportion of a terrestrial or stony matter: and so powerfully does our salt attract the moisture from the air, that I have seen it melted down in the containing glass, some time after it has been put up hot therein; tho' the vessel was first well dry'd and heated, and its mouth afterwards exactly closed with a cork and oiled bladder, three times doubled. If the lime be slaked before 'tis made use of in this process, the potashes will be less fiery, and the salt prepared from them of less virtue and efficacy. Therefore, the caustic property of this salt appears to proceed, in great measure, from the fire that is lodged and concentrated in the lime, and ashes; as well as that which they afterwards gain in the operation. But it is very remarkable, that the cause which makes our salt more corrosive, shou'd, at the same time, dispose it to flow with readiness in the fire. But when long exposed to the air, it loses its corrosive virtue, and runs into a liquor.

3. This salt is one of the most violent caustics we have, and presently liquifies and dissolves all the parts of a human body, as well solid as fluid; and consequently must be very serviceable, when properly made use of, in chirurgical cases. I make no question, that if this violent alkali were taken internally, in the quantity of but of a few grains, it would soon liquify, and dissolve away the very stomach it self. It seems to come very nearly up to the nature of pestilential salts, or those which cause the plague among us: only being more gross or fix'd than they, it acts chiefly upon the larger vessels of the human body; whereas the pestilential salts, being more subtile and volatile, are fitted to act upon the smaller parts thereof; and sometimes without appearing to affect the larger. But some degree of heat or moisture is absolutely required to bring our fix'd salt into action: when applied to the lifeless body of a man, it has no effect thereon. But being apt to run, flow and relent with very little heat, and very little moisture, 'tis wonderfully disposed for action; and becomes a most present remedy to stop the spreading of a gangrene, or mortification.

*Medicinal uses
of the producti-
on.*

*Corollaries
from the history
of vegetable
salts.*

4. Having now resolved our fixed salts up to the highest degree of simplicity and purity they are capable of being brought to by art, and increased their strength to the greatest degree we are able; let us see what conclusions may be drawn from the preceding history of them, as to their nature and production. (1.) It appears from our several processes, that the fixedness of these vegetable salts depends upon the action of the fire. Thus we can obtain them, by means of it, from all sorts of fresh, succulent plants, or such as are not too much dry'd or decay'd; but if vegetables to be thus treated, after having very long lain exposed to the air, they will yield no fixed salt at all: for in that case the air has left them in the state of the subject of our fourth process. The matter therefore of these alkaline salts is originally volatile; but rendered merely fixed by the operation of the fire. (2.) That they are the production of the fire; for there are no plants which manifest the least sign of an alkaline salt before incineration. The juices of plants are tartareous, oily, aromatic, acid, &c. but never alkaline. Our second process performed upon what vegetable subjects soever, will never extract an alkaline salt from them. But we constantly observe, that the greater the fire made use of in the incineration, and the better that is performed, the more of these alkaline salts we obtain. (3.) That alkaline salts are not the native or essential salts of plants. For being mere creatures of the fire, they cannot præexist in a plant; and therefore were not natural to it: nor do they ever appear till the plant itself is totally destroyed; whence they could not possibly be native, or essential. And consequently the native or essential virtues of vegetables do not depend upon such an alkali. (4.) That they do not naturally præexist in the subjects which afford them. I know that M. Homberg, an admirable and judicious chemist, is of another opinion; and therefore shall here endeavour to strengthen my own by an example or two. The plant sorrel confessedly contains an acid salt, and in what manner soever you examine it, without destroying the body of the plant, you will find it either acid or insipid, but never alkaline. But burn it to ashes, and it will afford our alkaline salt; provided it has not been too long exposed to the air. Whence I think it evident that such a salt did not exist in the plant, before it was reduced to ashes. We have already observed, that when any vegetable substances are kept too long, they lose their colour, smell and taste; and, when calcined, afford nothing that is saline in their ashes: and as this is the common case of all plants, what can hinder us from concluding, that the salt which thus vanishes, and is lost to the plant, was not a fixed alkali, but a volatile salt; since it is carried off, and made to exhale by so gentle a cause as the action of the air? And thus, if a whole lime-tree were reduced into thin shavings, and exposed for any considerable time, to the open air, and afterwards calcined, it would not afford a single grain

grain of fixed salt; provided the shavings of the wood were made sufficiently small and thin. The matter, therefore, which in a recent vegetable affords the fix'd salt, is so volatile, as in time to fly off spontaneously from its subject; and consequently no fixed salt does naturally præexist therein. (5.) That infinite species of salts may interpose between the fiery alkaline salt, and the native one of vegetables. Thus tartar, for instance, or the mild, and somewhat acid essential salt of grapes, will, with different degrees of calcination, successively appear under different colours, according to which, it will have different degrees of sharpness or acrimony. But it does not become acrimonious upon the first action of the fire; but rather fat, unctuous and black, so as in that case to afford the matter for the printer's ink; but the longer it is torrefied, or calcined the farther it is removed from its original or natural state, and the more alkaline it grows. So that the salt of plants is always mildest in the state wherein nature affords it; and continually rises in corrosiveness, with the degrees of fire to which it is exposed. There may, therefore, be infinite species of salts, and of different colours, between the native, and the last class of fixed ones afforded by vegetables. (6.) That the difference of salts, prepared by calcination, principally depends upon three causes, *viz.* 1st, The greater or less quantity of combustible matter, or oil, that adheres to the subject, or ashes; 2^{dly}, The strict or loose union of the oily principle with the saline; and, 3^{dly}, The quantity of fire, fixed, and made one with the salts themselves; or else the matter of it acting upon, and changing them, till they are incapable of any farther alteration. The greater quantity of oil any salt contains, the farther it is removed from the state of a perfect alkali. Thus, if tartar be torrefied, stifled, or lightly calcined to a black coal, it will become a benign and gentle medicine, capable of affording a fine lixivium with wine, and very proper to be given in dropical cases. But the more its oil is consumed by the fire, the more sharp and corrosive it grows; and at length, being still farther urged with the fire, which consumes its oily parts, it will turn to a violent, fiery, and white caustic salt, reducible by oil to a mild and inoffensive nature again. If we take two single pounds of tartar, and calcine the one in a strong, open fire, but barely torrefy and suffocate the fire in the other; the salt afforded by the latter will be more in quantity by a third, than that afforded by the latter; and of a much more gentle nature. And thus according to the care and skill of the artist in burning his vegetable subjects, they will be made to yield a greater or a less proportion of a mild, or fiery salt. For by means of a gentle heat, we see that the oil of a plant is intimately united with the salt thereof. We formerly observed in our *Theory of chemistry*, that the most subtile body of fire might be fixed; and tho' it were to remain in that state for the space of a hundred years, yet being at length, by some means or other,

Processes upon Vegetables.

ther, set free, it will appear in the form of fire again. Thus if quicklime, for instance, be kept in a dry place, where no manner of moisture can come at it, for ever so considerable a number of years, and afterwards be plunged into water, 'twill boil and bubble up with great violence and fury; upon which the fire is presently lost to the lime, and communicated to the water, which now makes the spirit in a thermometer to ascend; but being now set more at liberty than it was before, it soon flies off into the air: whence we may see, that quicklime is nothing but a parcel of fire lodged and detained in the gross, stony, or terrestrial matter whereof all lime is made. And after the same manner the fire enters, and wou'd make its escape from our fix'd salts, but remaining fixed therein is the cause of their corrosive, or caustic virtue; for they act altogether in the nature of fire. Being applied to any external part of the body, they immediately cause an itching, swelling, pungent pain and inflammation; blisters eating down into the flesh, and introducing a crusty scab; all which are the effects of fire it self; like which too, it will afterwards bring on a gangrene, or mortification. I cannot, therefore, give into the opinion of the great *M. Humberg*, who supposes there is but one salt in nature; and that an acid, combined with earth, in different proportions, is the cause of all that variety we observe in salts. For it seems no way probable to me, that such a degree of corrosiveness, as we find in the fixed species, should ever proceed from a mixture of earth; especially since we find that all the differences, in point of corrosiveness, between them are occasioned, either by taking away what was not salt before, I mean their oil; or else by the addition or application of fire, which is a thing that appears very different from salt. And from hence we learn, that fixed salts may be compounded of the oil, native salt, and earth of vegetables, united together, by means of fire, or else incorporated with it.

(7.) It appears that alkaline salts are capable of crystallization; which is contrary to the opinion of some eminent chemists. For after we had filtered, and rendered the deliquated oil of our salt, to appearance, perfectly pure and transparent; yet when it was set to rest in a cool place, it first grew thick or turbid, and afterwards shot to the bottom a true species of crystalline salt. This, indeed, is a surprizing phenomenon, and what a man would not readily expect. It should seem from hence, as if there were such things as seminal principles, or impressions, not to be destroy'd or alter'd by the power of art. And 'tis very remarkable, what *Mr. Boyle* observes of these crystals, where he admirably treats of the differences of salts, that tho' they shoot from so very saline and strong a lixivium, yet of themselves they are not corrosive; at most not so violently acrimonious as the salt from whence they were obtained. These salts, indeed, when only dissolved in water, do not so easily afford their crystals; but they do it in plen-

plenty, when suffered to run in the open air. Which may proceed from that wonderful property they have, of attracting other bodies, and uniting them with themselves; such as water, oil, air, &c. So that these crystals seem to be an alkaline salt impregnated with the salt of the air; which possibly may be of an opposite nature thereto. Thus we find, that by pouring vinegar upon salt of tartar suffer'd to run in the air, we may regenerate tartar, or produce it afresh; and so of the spirit of sea-salt, and the alkali of tartar, we can reproduce sea-salt; with the spirit of nitre, salt-petre; and with oil of vitriol, vitriol itself, bating the loss of its metalline part. (8.) In the last place, we may learn from our preceding processes, that the salts of animals proceed from the food and medicines they make use of. Some are of opinion, that because the parts of our bodies, when they come to be distill'd, yield a copious salt, they must be endowed with a faculty of forming it. But in reality, neither we, nor any other animals are possessed of any such a faculty; and can only change the salts taken in, along with such vegetable substances as are used for food, or physic, but never create, or make any. There is no vegetable substance capable of affording nutriment to the body, but what contains some quantity of salt. An ox, which feeds upon nothing but grass, has a large proportion of saline matter in his blood and urine; and an infant, who sucks nothing but milk, that is sweet to the taste, will still have his juices mixed with salt: which can happen from no other cause than this, that the salt of the vegetable substances, fed upon by animals, is extricated, and set free from the oil, or other parts, by the *vis vite* residing in them; and so, mixing with the blood, is suffered to pass off with the excrementitious juices. Only, upon account of the motion and brisk circulation perform'd in animals, these salts are more broke and attenuated than we find them in plants; as we shall make more fully appear, when we come to examine the subjects of the animal kingdom. And this is all we have here to offer upon the subject of vegetable salts.

CHEMICAL HISTORY of DISTILL'D WATERS.

*Introduction to
the history of
distill'd waters.*

THE order before laid down, requires us next to attend to the physical changes which vegetables undergo, by the joint action of fire and water, whilst they are contained in close vessels, that catch and condense the vapor or exhalations, which would otherwise fly off; and so present us with the invisible parts they lose by the treatment of our second and third processes; or whilst they remain in a state of decoction, under the form of a visible water. The doing of this we call by the name of *Distillation*. We are already instructed in the nature of decoction; but are not yet given perfectly to understand what its different subjects lose in that operation; or what it is which continually exhales from them in fume, vapor, or smoke, whilst that process is in hand. When we shall once be acquainted with this, we shall know the whole force of fire upon plants, whilst it acts through such a medium as water. But the only way of making this discovery is by distillation; which we define the method of condensing and collecting the vapors arising from boiling subjects, so as to render them visible, permanent, and capable of being examin'd by our senses. The parts of vegetables which usually come over in this manner, are their water, oil and salt. But in order to obtain each of them in perfection, and clearly to demonstrate the just effects of fire and water upon the subject, it is proper to observe this general method. (1.) The instrument made use of in different distillations, should, as much as possible, be the same alembic, furnish'd with its proper worm and refrigeratory. By an alembic, otherwise called *Vesica*, we mean a vessel of copper, whereto a concave, globular, or hemispherical, metalline head may be closely luted or cemented, so as to stop the rising vapors, and direct them to the tube which leads from it into the worm. The worm is a long spiral tube of lead, running thro' the refrigeratory, to transmit the condensed vapor, and discharge it at its lower aperture. The refrigeratory is a large wooden vessel, filled with cold water; through which the worm takes its course from the upper part, towards the lower. Its office is, to cool and condense the rising fumes, and cause them to come off in the form of a liquor. (2.) The subjects made choice of being put into the alembic above-mentioned, a sufficient quantity of clear water pour'd thereto, and the head luted on, that communicates with the worm; a proper degree of heat is to be applied, to make the liquor boil; whereby there will be obtain'd, in the form of water, whatever that degree of fire causes to rise; which the head keeps in and condenses, so that it runs off through thro' the

the worm. (3.) After this, in order to shew how such distill'd liquors may be enrich'd and improv'd to the purposes of medicine, it will be necessary to cohobate them; that is, to pour them back, instead of common water, upon more of the same kind of subject, and distil them off again, as before. (4.) And lastly, it will be convenient to shew what changes the same degree of fire, applied and directed in the same manner, will produce upon the same kind of subject, after it is fermented; and how its exhalable parts are thereby changed in their nature.

P R O C E S S X I V .

Exhibiting the common manner of Distilling WATERS from recent Vegetables, by an Example in the plant Rosemary.

1. **P**UT a sufficient quantity of rosemary, fresh-gathered, in its perfection, and cut moderately small, into a copper alembic, or vesica, so as, without much pressing, to possess about three parts of the body of the still; and then pour rain-water thereon, to an equal height with the plant: after this, lute on the head, with a mixture of linseed-meal and water, join its rostrum to the worm of the refrigeratory, lute the juncture, and place a proper receiving vessel at the lower orifice of the worm. (2.) Let the subject thus stand in infusion, with a small degree of heat, for the space of twenty-four hours; then increase the fire till the liquor begins to boil; which may be known by a hissing noise within the alembic, a violent heat perceivable by the hand applied to the top of the still-head, the smoking of the refrigeratory, and the drops which will now begin to fall apace from the worm into the receiving vessel. (3.) Continue the same degree of fire, so long as any thick, turbid, milky, frothy, odorous and sapid water will run off; or till a clear, insipid, scentless, or acid water begins to come away; and let the former liquor be carefully collected and kept by itself, without any mixture of the other; for this alone is the water required of our present process. The process.

2. The water put to the subject should not fill more than two thirds of the alembic, because it might otherwise easily rise so high in boiling, as to pass over the helm, and foul the distill'd liquor. The degree of heat employ'd, during the time the plant is infused, ought not to exceed that of the human blood in its natural state; which will excellently prepare it for distillation; by loosening and resolving the saline and oily parts of the subject. After this, the fire must not be made too strong at first; for in that case, a foul frothy matter would be made to rise and lodge itself in the worm; and part of the subject going over with the water, would clog the same, and render the water impure. Directions relating to it.

H

When

Processes upon Vegetables.

When a hissing noise is perceived in the alembic, and the head of the still is grown so hot, quite up to the end of its rostrum, that it cannot well be handled without pain, the water of the refrigeratory will smoke, and the liquor begin to distil gently; which are signs that the subject matter is duly agitated by the fire. For if the degree of heat employ'd should fall short of this, the subtile, oily, and volatile parts of the plant would not rise, but remain fix'd in the subject, or the infusion; so that only an insipid and insignificant water would distil off: but if the fire be raised too high, the boiling matter will run off too hastily, in the form of a decoction, and so foul the worm, and spoil the water. With this due degree of heat, therefore, we are to proceed, till all the water of any virtue is drawn off; or till an insipid, transparent, or acid kind of liquor begins to run; from which the other must, by all means, be separated, because it would, by reason of its acidity, give a tart taste to the water, and by corrupting the oil thereof, soon turn it rancid, and render it unfit for keeping; or else it would communicate a vomitive quality thereto: for being enabled, by the acid it contains, to work upon the copper of the still, it impregnates itself therewith, and so becomes emetic. Thus, I once remember, that having prescribed some cinnamon-water to an infant, contrary to my expectation, it caused her to vomit. Upon which, being presently called again, I examin'd the water, and found it of a greenish colour; from whence I conjectured, that the distillation of it having been too long continued, the liquor of the last running had corroded the copper head of the still, carried off some particles of the metal, and copiously mixed itself with that which first came away pure and perfect. At another time too, upon the same account, I saw a person thrown into convulsions by the use of a little mint-water. Whence we see what great mischiefs may be occasioned by ignorance, neglect, or savingness in the business of distillation. But in case such a hurtful distill'd liquor should at any time be used, instead of that which is pure and genuine, and a vomiting, or diarrhœa be excited by it, the proper remedy is to drink down large draughts of milk, or hydromel, or plentifully to inject the same liquors by way of glyster. If the distillation, therefore, be continued too long, the water will be impure; and if not carried on till all the odorous, thick, and milky part is obtained, it will not be perfect, or contain all the virtues of the plant, which ought to be gain'd from it by the operation; the design whereof is to give us a water, endued with the perfect smell and taste, or native oil of the plant, attenuated so as to rise in vapor by heat, and be condensed by cold into a liquor, which is always the richer and stronger, as it contains the more of that oil. And this is the common method practis'd by apothecaries, and others, in drawing off all their distill'd waters.

3. The vegetables best fitted for this process are the sapid and odorous, or such aromatic plants as were set down in our catalogue under the first process; and which, by the several processes we have gone through, appear to contain a large proportion of saline and oleaginous matter, or a substance that is saponaceous; the oily portion being of three kinds, viz. that which rises in the water of the first process; that which remains behind in the decoction; and that strong, glutinous substance which obstinately adheres to the remaining matter. All these vegetable subjects should be gathered for distillation in their prime, or whilst they are in the leaf, before they put out their flowers, or run to seed; unless we design to make use of the seed or flowers themselves. For 'tis a general rule, that plants lose thus of their virtue, especially of their aromatic parts, and spend themselves in their flowers and seed; at which time they therefore constantly appear to droop and languish. But whenever the flowers and seeds of vegetables are more odoriferous and aromatic than their leaves, we are to make choice of the latter for distillation; and these too should be gathered whilst they are in perfection. Thus, to gain the medicinal water of roses, or lavender, gather not the leaves, but the flowers of those respective vegetables, in their season, and commit them to distillation: but the seeds of some plants are to be preferr'd for the same purpose, as aniseed, for instance. In short, such vegetables, or such parts of them should always be chosen for this process, as are most aromatic, and abound most in oil; in which the virtues of these distill'd waters principally reside. And, therefore, those subjects which afford little or no native or essential oil, by distillation, are improperly treated by it. Thus it would be absurd to distil the *Peruvian bark*, in order to obtain a water therefrom, endowed with its febrifuge virtue, which does not reside in the essential oil of that vegetable*.

4. Hence we learn, (1.) What it is that ascends, in form of vapor, from an aromatic plant, by the heat of boiling water; viz. the water of our first process, the oil, natural acid, and volatile salt of the subject. (2.) What remains behind, after such an operation; viz. the decoction of our second, or the extract of our third process, or a mixture of the less volatile oil, and acid salt of the plant, diluted with water, together with the remains of those processes. (3.) What is the cause of the particular taste and smell of the plant, and in what part thereof it re-

* The whole art of pharmacy consists in treating the *materia chemica* in a manner suitable to every subject; so as to gain from it the parts and virtues we want, unimpair'd, and reduced to a form convenient for taking, and keeping, at all times, ready for use. We must of necessity be previously acquainted with the natures of vegetable, animal and mineral productions, and their several parts; have a

knowledge of menstruums, their properties and uses; and understand the effects of physical agents on them, with the manner wherein that action is perform'd, before we undertake to write pharmacopœias, or even extemporaneous prescriptions. 'Tis a jest to set about either, before we are masters of so much knowledge; and by so doing, shall only expose ourselves to the laughter of such as are judges in this way.

Processes upon Vegetables.

sides; *viz.* in its essential oil, or the water of our first process, wherein that oil appears to be greatly attenuated and exalted. (4.) What it is that exhales or flies off into the air in preparing decoctions; *viz.* the odoriferous spirit, or oil and water of our first process, with some portion of the essential, or native acid salt; the matter of the thick pitchy oil, or fix'd salt, and earth remaining behind. (5.) That at different distances of time, from the beginning of distillation, there run off waters of contrary properties and virtues. Thus, the first running is commonly aromatic, cardiac, and heating; but the second refrigerating and tart, after it has done running milky. And this is most highly remarkable in the distillation of *Indian* cloves. (6.) And, lastly, we learn from this process, how distillation is to be applied, regulated and directed, for the theoretical and practical uses both of chemistry and medicine.

Its use in medicine.

5. The medicinal virtues of waters prepared after this manner, are the same with those of the respective plants, from which they were drawn. Thus the distill'd water of mint is stomachic, that of wormwood, vermifugous, &c. for which we refer to the botanic writers; such as *Dioscorides*, *Dodonaeus*, *Ray*, &c. 'Tis observed by the *Sieur Rbedi*, in his experiments upon worms and insects, that the distill'd water of succory has the power to destroy them; which is more than either the expressed juice or decoction of that plant can effect. And, in reality, this virtue can only be attributed to the water of the last running in the distillation of succory, which, by reason of its acidity, frets and corrodes away some particles of the copper vessel in the operation, that give it the faculty. And the longer this latter part of the distillation is continued, the more acid the liquor grows; and consequently the better able to impregnate itself with the particles of the copper; so that at length it will, by this means, become highly emetic, and capable of suddenly destroying all manner of worms and insects. Whence we see, that in the case of succory-water, it is not the vegetable, but the metal, which is of force against worms. For the plant of itself has no such virtue, till its native salts are made to rise in distillation, and wash off or dissolve some particles of the copper.

PROCESS XV.

Exhibiting the manner of Cohobating WATERS distill'd per velicam, from recent vegetables; by an example in the water of the foregoing PROCESS.

1. **S**TRAIN off and press out the decoction of the plant, which remains The process.
after the preceding process is ended; and, pour it, together with all the pure aromatic water that was distilled over, without any mixture of the acid part which comes at last, upon fresh rosemary; so that the decoction, and the distill'd water, may together serve instead of a like quantity of common water. Then let them stand together in the alembic, with a moderate heat, for the space of three days and nights; and proceed in all other respects, after the manner of the fourteenth process; only let the fire be a little gentler than before.

2. The preceding process informed us what it is which the joint Its nature.
action of fire and water raises from vegetables by decoction, in close vessels, and what parts of them it leaves behind; and the present shews us a method of opening the bodies of plants to greater advantage, so that the waters they afford by distillation, shall be stronger, and more efficacious. This method we call by the *Arabic* name of *Cohobation*, which, as we before observ'd, signifies that kind of distillation, wherein, instead of common water, distill'd-water of the same recent plant is return'd upon a fresh subject, and the distillation repeated, in order to bring over a water that shall be more fully impregnated with the oily parts of the plant.

3. The water thus drawn off, will at first be as white as milk, and Nature of the production.
have a large quantity of oil swimming upon its surface. 'Twill most distinctly, and in great perfection, possess the smell and taste of the plant, appear thicker, more frothy, and in all respects much richer, and more efficacious than the water of the preceding process; and the oftner the cohobation is repeated, the more unctuous and noble it becomes. 'Tis its large quantity of oil that makes it appear so white; and therefore the whiter it is, the richer and better it must prove. By a number of successive cohobations, it will be so impregnated with oil, as to appear like a thick emulsion, or an *elaosaccharum*, as to its consistence. If this water be permitted to stand at rest for some time, it commonly drinks into itself, or takes up that from the oil, which gives the plant its peculiar scent and odour; whereupon the remaining oil becomes a light kind of mucilage, or soft wax. That which runs second, will contain but a small proportion of oil, tho' 'tis still richer than the first running in the

Processes upon Vegetables.

the preceding process. But that which comes off towards the end of the operation, will be perfectly simple and transparent; except that its taste may prove somewhat sharp or acid.

Reasons for the direction of the process.

4. The decoction of the preceding process, as well as the water of it, is here poured back upon the fresh subject, because being of a saponaceous nature, or consisting of a mixture of salt and oil, it greatly opens the vegetables wherewith 'tis boiled, and sets their principles free. And bodies are never better dissolved, than by menstrua analogous to themselves. We order the subject to stand in infusion for three days and nights, before the distillation is begun, and with such a gentle heat, as will, by no means, cause the liquor to boil; but if it were to stand in this state much longer, it might begin to putrefy, and so become unfit for our purpose. 'Tis the design of thus infusing our subject, to separate its more volatile parts from those that are more fixed; and since by such a method we excellently obtain that end, the operation is called *chemical digestion*.

How performable to best advantage.

5. When the vegetable subjects design'd for this process, are very oleaginous, aromatic, and hot, they ought first to be gently dried in the shade; then, being cut, and mix'd with thrice their own quantity of water, let them be suffered to macerate with a small heat, for the space of four days, in a close vessel, before they are committed to the still: and if rosemary, mint, baulm, marjoram, organum, sage, penny-royal, hyssop, savin, orange-peel, citron-peel, or any other vegetables which contain any quantity of balsam, be thus treated, they will afford most admirable waters. But those plants, whose odoriferous or medicinal parts soon spend themselves in exhalation, should be thrown into the alembic, as soon as they are gathered, and be distill'd off immediately, without any previous digestion. And thus violets, borrageflowers, lilies, roses, jasmin-flowers, &c. afford delightful, fragrant waters; their fragrancy consisting in a subtile spirit, and not in a viscous oil; which is the reason of its being so soon lost. When waters are to be distill'd from any kind of fragrant barks, or woods of a close texture, and a solid nature, they ought to be first shaved thin, and put to steep in water, made saline with a moderate quantity of sea-salt, and to be kept the longer in maceration, as their closeness is the greater, or as they are more resinous, ponderous, and durable. Thus the woods which sink in water, as box, guaiacum, rhodium, &c. ought to be steep'd, for the space of three or four weeks, before they are distill'd for their essential oils: during which time, the salt-water insinuates itself into, and by its attenuating quality, opens the bodies of them, keeps them sweet, and preserves them from corruption. But the lighter woods, as sassafras, for instance, are not to be treated in this manner; because the oil of them is subtile, and exhalable, and they afford a very strong scent, with a small degree of heat. The astringent, nutritive, laxative, emollient, gelatinous, styptic, and

and coagulating virtues of vegetables are never to be expected in the distill'd waters of them ; but in their decoctions, extracts, or express'd juices. This rule, well observ'd, would ease the apothecaries of a deal of trouble. Simple plantain water, and small cinnamon-water have just as much virtue, in case of a *diarrhœa*, as that which falls from the clouds. Who can help laughing to see pearls ordered for distillation, as they are in the royal pharmacopœa of *Germany* ? Some think they enrich their waters by throwing leaf-gold into the still along with the other ingredients ; but this is the way to impoverish the patient sooner than raise his drooping spirits. To use tormentil-water, ~~and Symplic~~, to do ing nothing for the good of the patient ; and, in short, to distil any manner of subjects, in order to obtain such parts of them as will not rise by decoction, is trifling with the world, and amusing our selves ; and therefore, all things of this kind ought to be expunged the art of physic *. There is, however, another species of cohobation, different from that abovementioned, by means whereof perhaps a few of the more fixed parts of vegetable substances might possibly be obtained upon distillation ; viz. by pouring back all that runs off upon what remains behind, at the same time that another fresh portion of the subject is also put in. And by this means a saturated water, or oil, may be gained from the *lignum sanctum* : but they are only the aqueous, spirituous, or finer oleaginous parts that can well be brought over even in this manner ; the rest must remain behind in the decoction ; which may, as we formerly saw, be boiled up to an extract. Whenever therefore the virtues of plants reside in these lighter parts, they may be distilled to advantage for medicinal uses ; otherwise they ought rather to be given in the form of a decoction, or extract. Thus, in case of the epilepsy we ought to give the water of lavender, and not its extract : but the decoction, or extract of cinnamon, should be taken for a *diarrhœa*, and not its distill'd water, which contains nothing of the astringent or earthy part of the bark. The advantage therefore of such distilled waters is, that they contain the specific scent and taste of the plant, or the essential oil thereof, in a great degree of perfection, separated from its other principles. But some plants are possessed as well of a fixed part that is medicinal, as this volatile one ; in such cases therefore, the distill'd waters should be mixed with the decoction, or extract ; by which means, all that is specific in the plant would be got together in a form proper for exhibition. This is the case of wormwood, southernwood, mugwort, carduus, centory, tansey, camomile, elder-flowers, juniper-berries, &c. the extracts, or decoctions whereof prove

* I know not whether a man would be more disposed to laugh, or rave, upon examining the most famous and approved dispensaries in *Europe*, with this key, to see how many errors of the like kind are committed in them. The ignorance of the compilers may indeed be laugh'd at ; but the condition of the poor patient, for whose service these labours were design'd, cannot fail to move our pity.

excellent, as well as their distill'd waters; which also may be greatly improved by fermenting the subjects before they are committed to distillation: but then their extracts are the worse for it. But that which is the cause of the native taste of the plant does not rise so easily, except when the plant is very aromatic; in other cases 'tis apt to remain in the decoction; especially when the subject is sweet, austere, acid or bitter. Wormwood, however, and camomile, by the force of cohobation, will yield a water of their own peculiar bitter tastes. Hence we see there must be a very great number of vegetables absolutely unfit for distillation: as not affording their particular virtues to the waters drawn from them. Such are sorrel, wood-sorrel, barberries, cherries, mulberries, strawberries, apples, ladies-mantle, currants, red and white, but not the black, which afford an excellent water; borage, succory, endive, plantain, cinquefoil, nightshade, sow-thistle, violets, lettuce, tormentil, purslain; and many of the plants enumerated in the catalogue under our second process, whose virtues are great in their extracts, but afford only an insipid water by distillation. But when we have an aromatic plant, whose virtues consist in its volatile oil, then our present process will give us them concentrated, as the chemists speak, or reduced into a narrower compass, and made greater than they were in the plant it self. Whence these cohobated waters are highly useful in the practice of physic.

Its use in medicine.

6. Thus by the repeated cohobation of mint-water, we may obtain, from the vegetable class, the most excellent remedy for vomiting, that I am acquainted with, except it be opium; as likewise in all hysterical cases, or where the matter of the gout is struck inwards upon the viscera; being taken in the quantity of half an ounce: which dose should be repeated once an hour till the cure is effected. Sydenham assures us that the same water is an admirable remedy in the *cholera morbus*; and, indeed, when thrice cohobated, 'tis almost infallible in that case. The distill'd water of baulm, cohobated in the same manner, gives great relief to hysterical women, and hypochondriacal or studious men, in fits of depression, or palpitation of the heart; and is one of the best medicines we have, when those cases happen in weakly constitutions, as they commonly do. Thus likewise the distill'd water of citron-peel is a wonderful remedy in fainting fits, or where a sharp alkali is suspected, as in the measles, small-pox, peripneumonia, &c. and might, I believe, be very safely employed in pestilential cases. Savin-water is an excellent emmenagogue, and may, when the body is rightly prepared for it prove a specific, if the cause be only the want of a stimulus. By preparation, I mean no more than that the patient shou'd first go into a warm bath, and after he comes out, take an ounce of this water; repeating the dose four or five times a day, as there shall be occasion. Camomile-flowerwater is, according to Pitcairn, a powerful medicine for tertian or quartan agues; and as well as the distilled and cohobated waters of wormwood,

and

and tansey hath the faculty of destroying worms in the human body, and bringing them away. Wormwood-water also is very beneficial to weak stomachs, it promotes digestion, and helps in colical cases; proceeding from a cold cause. And thus, by distillation and cohobation, we may gain other waters, of great virtue, from vegetables, and fit for several medicinal uses.

PROCESS XVI.

Exhibiting the manner of DISTILLING the WATERS of fermented Vegetables, per vesicam, according to the practice of Ludovicus; by an example in ROSEMARY.

1. **T**AKE rosemary, or any other aromatic, recent, succulent plant, gather'd in its prime; cut it into small pieces, or bruise it; pour thereon twelve times its own quantity of warm rain-water, and add about a fiftieth part of yeast; or an eighth of sugar or honey, in respect of the water; let all be put into a vessel of oak, placed near a fire, if it be winter, and well covered with clothes to keep the liquor warm, for the space of six or seven days; during which time there will arise an intestine motion, attended with a hissing noise, and a frothing on the surface, which will throw up the plant, and sustain it at the top: and this particular motion we usually call by the name of fermentation. (2.) When the operation has been continued its due time, the plant, which floated on the top, will fall to the bottom of the liquor; the hissing noise will cease, the froth subside, and the liquor, which before lay under it, appear, and send out a fragrant vinous odour: and now the plant is sufficiently opened to afford its virtues, or spirit in distillation. (3.) Commit the whole, therefore, to the alembic, and proceed to distil off the liquor, in the manner, and with all the cautions observed in the fourteenth process; being here more careful as to the regulation of the fire, because the matter in the still is more apt to boil over, than in the former cases. (4.) The phenomena of the liquor that thus runs off will vary with the degree of fermentation undergone by the subject. If the operation was perfectly performed, with a considerable proportion of honey, sugar, or yeast, there will come over a thin, limpid, fragrant, inflammable spirit, without any apparent mixture of oil; but if only a small quantity of yeast, sugar, or the like, was employed, and the fermentation was not continued too long, or raised to any great height, then a very white, thick, fat, frothy, odorous, sapid and penetrating water will be obtained, with a small proportion of a thin oil swimming on the top thereof. And this is the water intended by the present process.

2. In the first case, after the limpid spirit is run off, there will follow a white, milky, thick, fragrant water; and in the second, a thin, limpid, acid, ill-scented and refrigerating liquor comes away at last. After which, if the fire be increased, a kind of vinegar follows: But

I

when

Its effects farther continued.

Processes upon Vegetables.

when the fermentation has been long continued, tho' not till all the oil of the plant is entirely converted into spirit; the last running will be a mere insipid, or sub-acid liquor. If the fermentation should be long continued, or perfectly finished, and the clear liquor be committed to a proper wooden vessel, close stopp'd up, it would in a little time become very transparent and fine; and being now distilled, afford a sharper liquor, or inflammable spirit, without the least signs of oil: but it would retain nothing of the taste, smell, or specific virtues of the rosemary; so that it cou'd not be told by examination what the plant that afforded it was. We must observe, in the management of the fermentation, to proportion the degree of heat, and the quantity of the yeast or sugar, &c. to the season of the year, and the nature of the climate. The hotter the season or climate, the less yeast will the liquor require; and the sooner will the operation be performed. The whole process would, in *Asia*, be finished in the compass of two days. But the case above-describ'd is to be understood of the winter season, and a northern climate; where fermentation proceeds so slowly, that we are obliged to promote it by artificial heat; which, however, ought not to exceed that of the summer's sun with us. We are not tied down to the use of yeast, sugar, or honey, in this process; but *must*, or new wine, beer, the juice of casia, manna, and several other things will serve to raise a fermentation, as well as those. When the plant subsides, or sinks to the bottom of the vessel, 'tis a sign that the fermentation is finished, or has been continued long enough for our purpose; for whilst the subject was kept afloat, the intestine motion continued strong, and the air, which is a principal cause of fermentation, was not yet sufficiently extricated from the plant; but when it sinks, 'tis a sign that the air-vessels of it are broke, and the contents of them set free: whence the oil, which was before locked up in these cells, is now dispersed thro' the whole body of the liquor; at which time therefore the fermentation ought to be stopped, and not suffered to renew again; for in that case the spirituous parts being now set loose, wou'd fly away, and leave the remaining liquor, vapid, flat and dead. If it could be conveniently done, one wou'd chuse to ferment the subject with water alone; but we here require the assistance of some foreign body; because the plant it self affords but a light, or thin infusion, which of it self will never ferment kindly. Very thin liquors always require some glutinous or viscous substance, to forward and promote their fermentation: but in what manner this is effected we shall explain hereafter, when we come to give the full history of that grand operation. The oil of any subject totally vanishes after it has undergone a perfect fermentation; being by that operation subtilized, broke fine, and exalted into a spirit. Thus in the second case of the present process, the gross high-coloured oil of our fourteenth and fifteenth processes, is greatly thin'd, diluted, and brought nearer to the nature of a spirit; so as in some measure to unite
with

with water: but in the first case 'tis wholly converted into a spirit, capable of uniting with water. For when ever the native or essential oils of crude plants are so attenuated by fermentation, as thus to mix with water, then it is that they lose the name of oils, and assume that of spirits. The extract prepared from the remaining decoction of this process, contains much less of the virtues of the plant, than the remains of the two preceding processes; whence we may form this rule, that the more a vegetable is fermented, the stronger or more spirituous will be its distill'd water, and the less the virtues that afterwards remain in the decoction: for fermentation always dissolves and considerably loosens some parts from the subject.

3. Hence we learn, (1.) That the specific taste and scent of plants, *The chemical doctrine it affords.* communicated to their distilled waters, depend upon the oil of the respective subjects. (2.) That by fermentation, as well as a long continued decoction, and repeated cohobation, the oils of vegetables come nearer to the nature of spirits; or are thereby rendered easier to mix with water. (3.) That the finer the oils of vegetables are broke by repeated operations, the more they lose of that specific principle which distinguishes them from one another. (4.) And lastly, that fermentation has a great power to alter vegetable subjects, so as to render them capable of affording waters of wonderful properties, and very different from those they were before possessed of.

4. The medicinal virtues and uses of distill'd waters, prepared after the manner of our present process, are very considerable. For, (1.) *Medicinal virtues and uses of its productions,* They contain the oil of the plant in great perfection; so that the specific virtues of aromatic vegetables may hence be obtained to advantage. (2.) They are very well suited to carry the essential oils of plants into the blood and juices, and to mix them therewith: they also act powerfully upon the coats of the œsophagus, stomach and intestines. Thus the distill'd water of fermented orange-peel, for instance, might be given, as a stomachic and cordial, with all the advantages that a physician cou'd desire. And (3.) These waters are much better fitted for keeping than those of the fourteenth and fifteenth processes, and will long continue good and perfect; because the spirit in them prevents their corrupting or growing mothery; so that when kept in a well closed vessel, the oil will rise to the top, whence they lose their milky colour, become perfectly transparent, and improve in their virtues. Cohobated waters may, indeed, be kept tolerably good, for almost the space of two years; tho' they are apt to grow mothery or ropy in that time; but those prepared by fermentation will continue unaltered, and in their full virtue, for six or eight years together.

PROCESS XVII.

*Exhibiting the manner of distilling WATERS from VEGE-
TABLES per descensum, by an example in ROSEMARY.*

The process.

1. **P**UT rosemary, or any other recent, succulent plant, capable of affording an extract, or a distilled water to advantage, into a linen cloth fixed round the brims of some proper vessel, that is made deep and large; or into a hollow metalline plate, perforated in several places, and fixed in the same manner to the edge of the vessel; which is to be closed with a metalline cover made for the purpose, so that no vapor may exhale at the juncture. (2.) Let a moderate charcoal-fire be kindled upon the cover, which, being made hot thereby, will liquify and dissolve the more moveable parts of the subject, and cause them to descend, partly in the form of vapor, and partly in that of drops, to the bottom of the vessel, whose office it is to receive the liquor thus made to descend.

The cautions it requires.

2. Care must be had not to make the fire too strong; lest it should greatly mix and confound the parts of the subject among one another, or render the water empyreumatical. This may be easily prevented by keeping the fire covered up with its own ashes. The deeper the vessel which is made use of in this operation, the cooler the season wherein it is performed, and the less the fire at first employ'd therein, provided it be afterwards raised by gentle degrees, in the greater perfection will this water be obtained.

It's effects.

3. As the more moveable or volatile parts of vegetables are the aqueous, gummy, resinous and saline, these are what we must expect in the water of this process; the heat employed being so great as to burst the vessels of the subject: but some plants contain so large a proportion of oil, that this will sometimes be found swimming on the surface of the water.

It's uses.

4. We see, therefore, that the waters of this process will nearly afford us all the native virtues of the plants submitted to it; or a mixture of their several parts: whence they, in a manner, come up to the express'd juices, or extracts gained from them. But as only a small quantity of water can be obtained by this operation, a mixture of the distill'd waters of our first, fourteenth, fifteenth, or sixteenth, processes, with the decoctions of our third, may be exhibited with greater convenience, and to equal advantage. Paracelsus, however, highly commends the water of guaiacum, prepared after this manner, in venereal cases; and perhaps it might prove a powerful sudorific; but the medi-

medicine must needs be very nauseous, strong, and disagreeable. 'Twas possibly this recommendation of *Paracelsus*, that occasioned this kind of distillation to be so frequently practised in *Germany*.

P R O C E S S X V I I I.

*Performed upon the REMAINS of the four preceding processes;
by reducing them to ashes.*

1. **T**AKE all that remains in the still after any of the four preceding processes are finished, dry the plant, exhale away the decoction, and at length reduce them to ashes by an open fire, in an iron vessel, after the manner formerly described; and these ashes will be found as saline, as those obtained by our fifth and sixth processes; only they will not prove quite so strong as if the subjects had never been distilled; and greater allowance must be made for those afforded by the remains of that subject which had been fermented.

2. Whence we see what it is that ascends in preparing decoctions, ^{its use.} and performing of distillation; and what it is which remains behind after those operations are finished. The native spirit, essential oil and water, with a small proportion of the native salt of the plant, are all the parts that rise in decoction, or distillation; the more fixed oil, and salt, with the whole quantity of earth remaining behind.

CHEMICAL HISTORY of VEGETABLE OILS.

1. **A** Vegetable oil is that moist, fat, viscous, inflammable part of a plant, which is either naturally liquid, or grows thin with a small degree of heat, but will not mix with water. ^{Introduction to the history of vegetable oils.} We call it moist, because it wets or sticks to the fingers of such as handle it; fat, because it is very soft and slippery to the touch; viscous, because its parts when united, adhere together, and obstinately stick to the bodies they touch, which no other part of a plant will do; inflammable, because it will flame away, and be wholly consumed in the fire: lastly, we say, it will not mix with water, because whenever it is so mixed, it is no longer oil, but an unctuous, or oily matter; and this property distinguishes it from spirit, which is an oil so subtilized as readily to mix with water.

2. In this part of vegetables resides that matter, which being generally the cause of their taste and scent, so effectually determines the particular

Processes upon Vegetables.

ticular nature of each; tho' it must be allowed, that in some very tart vegetables the oil is insipid. Otherwise when this liquor is extracted from vegetables, the remaining parts lose all their smell and taste. Thus when cinnamon or cloves are deprived of all their oil, we can only distinguish them by their figure from other woody substances, or from one another. We may therefore conclude, that the distinguishing, sapid, and odorous principle of vegetables generally resides in their oil. But we do not assert the oil itself to be this principle; that being no more than the bare vehicle of the spirit which constitutes it. This oil is otherwise called by the name of sulphur; whence some chemists have said, that the sulphur of plants is the seat of their spirit.

3. This oil is often separately contained in the peculiar vessels or cells of plants, call'd by *Malpighi loculi terebinthinacei*, which are to them what the adipous membrane is to us; or otherwise it is intimately mixed with their saponaceous juices. Pure oils of the former kind are frequently found, under the form of gums, rosins, or balsams, lodg'd in the bark and seeds of plants; that is, in their more durable parts; and those which lye most remote from the roots, or aqueous juices. They sometimes, indeed, may be found in other parts, but never in any considerable quantity. Thus if a piece of master-wort-root, for instance, be cut and examined with a microscope, we shall find the oil distilling from distinct cells of the root; but the same may better be observed in a nutmeg, walnut, almond, &c. when their parts are separated with a hot knife. The bark of a tree, as well as the seed, must be esteemed a part remote from the roots, because the nutrimental moisture appears principally to enter the woody parts of the tree, as if they were arteries; and to return by the bark, as if that consisted of veins. Hence, when the bark of a tree is cut, its oily cells are visible to the naked eye, or at least may be discovered by the microscope; as particularly in the pine-tree, the walnut, &c. and when wounded, it sometimes distils its oil in the form of a gum, as that of the cherry-tree; or in a more fluid form, as in the turpentine-tree. At other times the oil will flow spontaneously from the tree: that is, when too great a quantity is lodged therein, it breaks its way thro' the bark; and in the same manner some seeds and fruits will also burst and discharge their oil.

4. These oils are always to be found in the greatest plenty, when the plant is at its full growth, at the time its sleeps, as it were, or when it is grown old. When a plant is young, it contains only a watery juice. Thus flax, soon after it is first sown, rises in the form of grass, and is altogether as aqueous; but when come to maturity, its seed abounds in oil, of which it contains, perhaps, a larger quantity than all the other parts of the plant. And so likewise young pines, fir-trees, &c. afford no turpentine; being, as yet, of too aqueous a nature. A vegetable is said to sleep during the winter-season, when it has lost its leaves; and to be

be awake and lively in the summer. During the time of their rest, a quantity of oil is laid up in them for their defence against the cold; and in proportion to the degree of it which they are to sustain. Whence it is, that the trees of northern climates so much abound with oil. If a tree in this season be deprived of its oil, it presently perishes; and therefore when it comes on, the pines, the firs, &c. contract themselves, shut themselves up, and distil no more of their oil; but keep it as a defence from the injuries of the weather. For oil, being incapable of congealing into ice, is excellently fitted for this purpose. And hence we see that those trees which contain it in the greatest plenty, are evergreens. A tree is said to grow old, when 'tis clogg'd and choak'd up by its own oil. Thus we constantly observe that the oldest trees, as pines, firs, &c. are suffocated by their own fat or turpentine, where-with their bark is so stuffed, that the juices can no longer circulate, nor respiration be continued in them; at which time, therefore, they must necessarily dye, as an old man does when suffocated with his own phlegm. And in this manner I have my self seen old fir-trees perfectly choak'd by the large quantity of oil or pitch that was block'd up in their bark.

5. From hence we may learn, that vegetables contain the greatest quantity of oil when they least abound in salt, when the seed is fully ripe, when the flowers are gone, and the leaves fallen off. Hence skilful architects constantly order their timber to be cut in the winter season; as proving then most durable, and free from the worm. For all wood is durable according to the proportion of the oil or rosin it contains. Thus guaiacum, and the red-wood used for cabinets, will endure for many ages. But when we would gather vegetables for the sake of their salt, we must take them in the spring season, before they bear fruit; for during the autumn, the salt, with the other juices, falls down into the roots; so that a pound of the wood of the lime-tree, or vine-cuttings, taken and burnt to ashes in the month of *October*, will not yield so much salt by a third part, as the same quantity wou'd do in the month of *April*.

P R O C E S S X I X .

Exhibiting the manner of obtaining the native OILS of vegetables by expression, in the treatment of Sweet-Almonds.

1. **T**AKE sweet-almonds, or any other kind of ripe nuts, or seeds, that *The process* have been gently dry'd in the shade, and grind them, together with their skins, into a kind of paste or powder; which, being first exposed, for some time to the free vapor of hot water, is to be put into strong linen bags, or strainers, and so placed between two warm iron plates, and committed to a strong press, which

Processes upon Vegetables.

ticular nature of each; tho' it must be allowed, that in some very tart vegetables the oil is insipid. Otherwise when this liquor is extracted from vegetables, the remaining parts lose all their smell and taste. Thus when cinnamon or cloves are deprived of all their oil, we can only distinguish them by their figure from other woody substances, or from one another. We may therefore conclude, that the distinguishing, sapid, and odorous principle of vegetables generally resides in their oil. But we do not assert the oil itself to be this principle; that being no more than the bare vehicle of the spirit which constitutes it. This oil is otherwise called by the name of sulphur; whence some chemists have said, that the sulphur of plants is the seat of their spirit.

3. This oil is often separately contained in the peculiar vessels or cells of plants, call'd by *Malpighi loculi terebinthinacei*, which are to them what the adipous membrane is to us; or otherwise it is intimately mixed with their saponaceous juices. Pure oils of the former kind are frequently found, under the form of gums, rosins, or balsams, lodg'd in the bark and seeds of plants; that is, in their more durable parts; and those which lye most remote from the roots, or aqueous juices. They sometimes, indeed, may be found in other parts, but never in any considerable quantity. Thus if a piece of master-wort-root, for instance, be cut and examined with a microscope, we shall find the oil distilling from distinct cells of the root; but the same may better be observed in a nutmeg, walnut, almond, &c. when their parts are separated with a hot knife. The bark of a tree, as well as the seed, must be esteemed a part remote from the roots, because the nutrimental moisture appears principally to enter the woody parts of the tree, as if they were arteries; and to return by the bark, as if that consisted of veins. Hence, when the bark of a tree is cut, its oily cells are visible to the naked eye, or at least may be discovered by the microscope; as particularly in the pine-tree, the walnut, &c. and when wounded, it sometimes distils its oil in the form of a gum, as that of the cherry-tree; or in a more fluid form, as in the turpentine-tree. At other times the oil will flow spontaneously from the tree: that is, when too great a quantity is lodged therein, it breaks its way thro' the bark; and in the same manner some seeds and fruits will also burst and discharge their oil.

4. These oils are always to be found in the greatest plenty, when the plant is at its full growth, at the time its sleeps, as it were, or when it is grown old. When a plant is young, it contains only a watery juice. Thus flax, soon after it is first sown, rises in the form of grass, and is altogether as aqueous; but when come to maturity, its seed abounds in oil, of which it contains, perhaps, a larger quantity than all the other parts of the plant. And so likewise young pines, fir-trees, &c. afford no turpentine; being, as yet, of too aqueous a nature. A vegetable is said to sleep during the winter-season, when it has lost its leaves; and to be

be awake and lively in the summer. During the time of their rest, a quantity of oil is laid up in them for their defence against the cold; and in proportion to the degree of it which they are to sustain. Whence it is, that the trees of northern climates so much abound with oil. If a tree in this season be deprived of its oil, it presently perishes; and therefore when it comes on, the pines, the firs, &c. contract themselves, shut themselves up, and distil no more of their oil; but keep it as a defence from the injuries of the weather. For oil, being incapable of congealing into ice, is excellently fitted for this purpose. And hence we see that those trees which contain it in the greatest plenty, are evergreens. A tree is said to grow old, when 'tis clogg'd and choak'd up by its own oil. Thus we constantly observe that the oldest trees, as pines, firs, &c. are suffocated by their own fat or turpentine, where-with their bark is so stuffed, that the juices can no longer circulate, nor respiration be continued in them; at which time, therefore, they must necessarily dye, as an old man does when suffocated with his own phlegm. And in this manner I have my self seen old fir-trees perfectly choak'd by the large quantity of oil or pitch that was block'd up in their bark.

5. From hence we may learn, that vegetables contain the greatest quantity of oil when they least abound in salt, when the seed is fully ripe, when the flowers are gone, and the leaves fallen off. Hence skilful architects constantly order their timber to be cut in the winter season; as proving then most durable, and free from the worm. For all wood is durable according to the proportion of the oil or rosin it contains. Thus guaiacum, and the red-wood used for cabinets, will endure for many ages. But when we would gather vegetables for the sake of their salt, we must take them in the spring season, before they bear fruit; for during the autumn, the salt, with the other juices, falls down into the roots; so that a pound of the wood of the lime-tree, or vine-cuttings, taken and burnt to ashes in the month of *October*, will not yield so much salt by a third part, as the same quantity wou'd do in the month of *April*.

P R O C E S S X I X .

Exhibiting the manner of obtaining the native OILS of vegetables by expression, in the treatment of Sweet-Almonds.

1. **T**AKE sweet-almonds, or any other kind of ripe nuts, or seeds, that The process have been gently dry'd in the shade, and grind them, together with their skins, into a kind of paste or powder; which, being first exposed, for some time to the free vapor of hot water, is to be put into strong linen bags, or strainers, and so placed between two warm iron plates, and committed to a strong press, which

which being gradually screwed tight, the oil will run from the subject, such as it originally præexisted therein.

*How perform-
able to advan-
tage.*

2. The subjects of this process should be fully ripe, at which time they are most unctuous; otherwise a saline matter might predominate in the oil: and 'tis necessary to dry them, or by stopping up the stalk, to hinder the water from rising into them from the earth; or else they would afford an emulsion instead of an oil. The vapor of the water, whereto they are ordered to be exposed, serves to open the body of them, resolve the oil, and free it from its cells. The heating of the iron plates conduces to the same purpose: but care must be had that they are not made too hot; for in that case they would give an empyreumatical taste and smell to the oil; which is very disagreeable, and ought by all means to be avoided. And if these cautions are duly observed, a native oil may be expressed from any kind of nuts or seeds, or other parts of vegetables, tho' they appear ever so dry or destitute of oily matter.

*The Nature of
the production.*

3. The oils, thus fresh expressed, retain in some measure the nature of the vegetables; from whence they were obtain'd; but contain only a small proportion of the native salt and spirit of the plant; whence some of them appear much of the same general nature. Thus the expressed oil of mustard-seed is sweet and mild, and does not differ greatly from the expressed oil of olives: whereas, that gain'd from it by distillation, being thereby mix'd with the salts, is very pungent, acrimonious and aperitive. But all of them upon being long kept, grow rancid, lose their mild and gentle nature, and become exceeding sharp, corrosive, inflammatory, caustic and poisonous. Thus if the oil of our present process, that of sweet-almonds, were to stand in a hot place, or in the open air, for a fortnight or three weeks in the summer-season, it would have a very pungent, nauseous taste, and if drank, occasion violent inflammatory disorders; for it is then as great a caustic as euphorbium itself*. And this may be the reason why the bile in animals, which is an unctuous humor, when too long detain'd becomes so sharp and corrosive, as to occasion terrible disorders. Whenever, therefore, a physician prescribes the use of expressed oils, let him be careful to order that they be fresh-drawn. The fat of a human body appears to consist of such oil as that of this process; and what is very surprising, seems to be readily made from vegetables, which contain but very little of it. Pasture-grass affords the least quantity of oil of any vegetable we know; yet oxen, by feeding upon this alone, will turn almost wholly into fat and oil. Whence we have but little reason

* Apothecaries cannot be too careful in the choice of the express'd oils, so frequently prescribed in pleuritic and other inflammatory

cases: the ill success so often met with in such distempers may sometimes be owing to a neglect herein.

to expect the cure of an unwieldy fatness in the body, from the use of a lean diet ; or from any thing else but fasting, labour, and sorrow of the mind ; tho' sea-salt, sal-ammoniac, vinegar, sugar, and the like resolvents, are allow'd to be serviceable therein.

4. The medicinal virtues of vegetable oils, thus fresh express'd, *Its medicinal virtues.* are lenient, relaxing, anodyne and balsamic. For, having no acrimony of their own, they abate the force of it in the body, relax the fibres, make them flexible and pliant, open obstructions, smoothe the passages, heal up wounds, cause dry scabs and eschars to fall off, &c. Hippocrates, in case of violent pain, recommends a draught of such express'd oils, with water. Thus the oil of sweet-almonds, when externally applied, assuages the violent pain of any part that has been over-stretch'd ; and if rubbed upon a musical string, would suffer it to be stretched out longer, than it otherwise could, without breaking. So likewise when the skin is besmear'd therewith in the small-pox, or a burning fever, 'tis of very great service in relaxing the pores. The same medicine proves excellent also in all spasmodic and inflammatory cases, as the quinsy, pleurisy, convulsions, &c. Fresh-drawn linseed oil is greatly commended in fits of the colic, inflammation of the lungs, and pains of the stomach and kidneys ; and the expressed oil of mustard-seed in all cases of the stone ; being taken in the quantity of an ounce or two, as there is occasion.

PROCESS XX.

Exhibiting the manner of obtaining Vegetable OILS by Emulsion ; in the treatment of Sweet-Almonds.

1. **I**F instead of committing the almonds, or other proper subject, prepared *The process.* after the manner of the nineteenth process, to the press, they were gently ground with clear warm water, in a marble mortar, their oily part would dissolve therein into a sweet, thick, turbid, milky liquor, in every respect, when strained off, like the chyle in an animal body ; and which we call an Emulsion.

2. This emulsion may be prepared from all manner of nuts and seeds, but from no other parts of a plant. The operation takes out from the subject, the oil, and whatever else is soluble in warm water ; whence the emulsion must contain some quantity of salt. And if the remains be now squeeze'd in a press, they will afford no more oil, which by the motion, or attrition, required to fit the subject for this process, is so broke and attenuated, as readily

Processes upon Vegetables.

dily to mix with water, and turn it to a milky, white, saponaceous, mealy liquor.

Nature of the production.

3. If this liquor be suffered to rest for the space of five or six hours, in a cool season, or four in a warm one, it will, like the chyle of the human body, spontaneously separate into two different parts; a cream, or butyraceous matter, which floats on the top; and a whey, or, aqueous part, which remains below, and soon turns of a blue colour and grows sour. Whence we may learn, that emulsions, when prescribed as medicines, ought never to be kept above six hours in the winter, and four in the summer, before they are made use of.

Mechanical use of the process.

4. This operation, in a simple and wonderful manner, explains the action of the mouth, œsophagus, stomach and intestines, upon the aliment taken in. Two actions, with their effects, cannot be imagined more alike, in all their circumstances, than these. The things we principally feed on are mealy feeds, or bread, fruits, &c. upon all which, the teeth and jaws act as the pestle and mortar in our present process; only nature makes use of the saliva, bile, and pancreatic juice for the menstruum; whilst our artist employs nothing but water. The stomach and intestines are the press, driven by the force of the peristaltic motion; and the lacteal vessels, the strainer, to separate the pure emulsion from its faeces, or chaffy matter which remains behind in the intestines. Whence we have the reason why the chyle is white, rather than of any other colour; namely, because the salt, oil, and water of our food are mix'd and blended together, in such a particular manner as always constitutes whiteness in liquors, or turns them into emulsions; tho' the food itself might originally be black, or of any other colour.

The doctrine it affords, with regard to natural philosophy and medicine.

5. Hence we may understand, (1.) The origin and rise of oil, both in vegetables and animals. The alimental juices of vegetables being suck'd in by their absorbing vessels, driven about by the force of circulation, and agitated by the heat of the sun, at length deposit their more unctuous, thick, and glutinous parts in their passage, or in proper cells, destin'd by nature to receive it. After the same manner in animals, this oily substance is taken in along with their food, and at length deposited in the adipous cells; for we have before observed, that no vegetable substance is nutrimental, except it contains some proportion of oil: even grass abounds therewith, especially in its feed; so that being thoroughly mixed with the saliva, it turns milky; and, accordingly, there are some men would grow fat tho' they lived, perhaps, only upon bread and water. (2.) The nature and use of native vegetable oils. (3.) The manner wherein they may be changed into a milky liquor. (4.) The difference there is between them and other vegetable oils, gain'd by distillation; which will more fully appear hereafter. (5.) The origin and composition

position of chyle and milk in the human body; with the means to increase the latter in nurses. Milk appears to differ from chyle only as having been more concocted, and containing a larger proportion of salt, which renders some part of it convertible into curd, or a caseous substance, which neither chyle, nor an emulsion is capable of. Milk, therefore, is an oily, vegetable matter, circulated first in plants, then in animals, and capable of being reduced into a thick curdy substance, and a thin waterish one, which is called whey. This milk, if it finds no opportunity of passing off in its own natural form, turns to fat, or goes away with the urine and sweat, which is most commonly the case in men; for they generate milk as well as women, tho' they have not their vessels so well disposed to separate it from the blood. 'Tis also observable of milk, that the longer it circulates in the animal body, the more it loses of its own vegetable nature, and puts on that of the animal. Hence the rank taste in the cheese of *Liege*, which is made of the second milk, or that drawn from the cow an hour after she has afforded her first meal. Both the chyle and milk can only be composed of those parts of the food which are soluble in the saliva, bile, and other juices of the body, and capable of being expressed out by mastication, or the force of the stomach and intestines; such are, in particular, all mealy seeds, and oleaginous food that will readily dissolve in water, or the fluids made use of as drink. (6.) Lastly, we may hence understand why milk and chyle are so apt to turn acid; for this is the property of vegetable juices, which affect a kind of fermentation, and to which the chyle and milk of animals are very nearly allied.

P R O C E S S XXI.

Exhibiting the method of obtaining Vegetable OILS by Coction; from an Example in the Remains of the two preceding processes.

1. **I**F, when by either of the two preceding processes the native oil seems to be entirely expressed, or drank up from the subject, the remains be for a long time boiled in water, over a strong fire, there will appear swimming on the surface, an unctuous matter, partly in the form of froth, and partly in that of a fat substance; which being lightly scumm'd off as it rises, and put to the rest, will at length amount to a considerable quantity of oil. *The process.*

2. This was first observed by the excellent M. Homberg; and if any recent, and very unctuous vegetable substances were to be thus treated, *How perform-
ble to aduan-
tage.*

such as almonds, cocoa-nuts, &c. they would afford two thirds of their original quantity in oil. And such bodies as will not afford their oil by expression, or by grinding them with water, may, by this method of decoction, be made to yield it in plenty. Thus several fruits, plants, and seeds, and particularly beans, being gently dried and bruised, will, by boiling, give out a copious oil.

The nature of the production. 3. The oils obtained after this manner, have all the general properties of express'd oil, but retain nothing of the peculiar virtues of the subject; for these either fly off in the operation, or remain in the decoction. They contain a combustible matter, which is usually found in extracts, and cannot be rendered volatile by boiling; and whatever is not volatile, with regard to the degree of fire here employed, must stay behind, either in the subject or decoction.

The process carried higher. 4. If the decoction be, at length, exhaled away to the consistence of an extract, it will be found to contain a large quantity of salt; which being detained by the water of the decoction, could not rise to mix with the oil.

P R O C E S S XXII.

Exhibiting the manner of obtaining the Native, or Essential OILS from the Leaves of Vegetables, by distillation; in the treatment of the leaves of Rosemary.

The process. 1. **T**AKE the leaves of rosemary, or any other plant, gathered in perfection, and gently dry them in the shade, till the more fluid part of their water is exhaled away; then cut or bruise them, and pour thereon ten times their own quantity of pure rain-water, acidulated, or made gratefully acid with a little oil of vitriol; and thus let them stand in digestion, with a very gentle heat, for three or four days; and afterwards distil off the water with a brisk fire, till it begins to run insipid or acid, as in the common case of distillation, before described; for the essential oil of the plant will come all away with the distill'd water; from which it may be separated after the manner which we shall shortly deliver*.

How performable to advantage. 2. All manner of plants, with their several parts, as flowers, seeds, bark, wood, &c. are fit to undergo this process; but especially the aromatic and oily vegetables. Even grass, thus treated, would afford some quantity of oil, tho' slowly, and with difficulty. But those subjects, or parts of vegetables, are the most proper to be treated in this manner which are highly odoriferous, when their more watry

* See the thirty-first process.

part is by gentle exiccation driven away. For which reason, the flowers design'd for it, should be gathered whilst they are crisp, or before they open and expand themselves entirely; and the leaves, before they are fully unfolded. These subjects ought always to be dried gently in the shade, because the heat of the sun, in exhaling their superfluous water, would carry away a great part of their fine volatile oil too; leaving the rest united with the fixed oil, and unfit to be diluted or softened with warm water. Thus mint gathered in the month of *May* or *June*, and gently dried, will yield a greater plenty of oil than at any other season; tho' it may at all times be had fit for distillation. But the oil of this process comes over more light and subtile, tho' in much less quantity from the flowers, than it does from the leaves of plants.

3. The whole secret of the digestion consists in this, that after the subject has once been a little dried, it may again be soften'd, so as to relax the fibres of the vessels containing the oil, that it may easily be melted down, and come out readily, after those vessels are burst by the heat. Spirit of sea-salt, oil of vitriol, or any other acid spirit is added, to the rain-water to fetch out the unctuous parts of the subject, preserve the whole from putrefying by so long a digestion, and keep in the natural scent thereof; which would otherwise be lost, and a fetid, or disagreeable one be found in its stead. This method ought more particularly to be observed in distilling the oils of very costly plants, because it doubtless increases their quantity considerably: not that it adds to the oil; but as there are two kinds of it in plants, one which is found pure and unmixed with any thing else, and another which is united with the matter of the alkaline salt of the subject, the acid made use of by drawing to itself that alkaline salt, sets the oil free to ascend in greater quantity with the distill'd water. Thus were I to distil cinnamon for its oil, I would first digest the bark with acidulated water for some days, and then the operation, as Mr. *Hornberg* has taught, will be much more gainful and advantageous. But the quantity of the acid to be added, and the time of digestion, are to be proportioned to the closeness and specific gravity of the subject. Thus, when we are to distil dry herbs, whose leaves are hard, or brittle, and not disposed to unfold themselves in water, or give out their oil, we may put them into a kind of brine, or rain-water made saline with sea-salt; and then digesting them for a proper time, as a week or two, in a close vessel, the subject will thereby be so mollified, as easily to part with its oil, by a brisk distillation. And this is the great secret practised in *France* and *Germany*, in distilling the oil of *jasmin*, &c.

4. Another secret with some persons, in order to increase the quantity of their essential oils in distillation, is, instead of common water, to pour the distill'd water of the subject back upon more of the same, or even to use the cohobated water for that purpose; for as the wa-
ter

ter impregnates, or saturates itself with the oil of the plant in the first or second distillation, it can afterwards absorb no more; and therefore leaves the rest free to ascend along with the other water that runs off. But as to what some authors write of increasing the quantity of distill'd oils, by the use of certain mixtures, as if they by that means caused the plant to afford more of it than what it naturally contained, 'tis trifling to pretend to any such thing; since 'tis not in our power to create oils, but only to separate them from the subjects wherein nature has lodged them.

How to be conducted.

5. 'Tis particularly requisite here, that we begin the operation with a brisk fire, which is another means of increasing our quantity of oil; for thus we shall prevent what is already separated and dissolved, from falling back, entangling with, or sinking into the subject again; which it would do, if a slow fire were used. But we must immediately stop all farther proceedings, as soon as ever the acid liquor begins to run; otherwise we should foul our oil, and cause it to grow rancid. When the flowers or leaves of *European* plants are made the subject of this process, the oil, that comes over, swims on the surface of the water; but that obtained from the aromatic vegetables of *Asia* and *America* always sinks to the bottom: and in both cases it appears of a different colour, and is obtained in different quantities, according to the nature of the plant.

Its rationale.

6. This operation, then, appears to be perform'd in an easy and mechanical manner. For the oily vesicles of the plant being first soak'd and soften'd, are broke by the action of the fire; or their contents so dissolved by the heat, that they mix with the boiling water; whence, by the continued action of the fire, they rise in the form of vapor, along with the water, and are stopp'd and condensed by the still-head, and forced to run out cool through the worm of the refrigeratory; and so a liquor comes away that is richly impregnated with the scent and taste of the subject. The degree of heat here made use of, being no more than that of boiling water, is unable to force up any of the solid parts of the plant, but only raises such as are liquid and volatile; whence the oils are supposed to come away pure, not greatly differing from what they naturally were in the plant: hence, among the chemists, they are not improperly called essential oils; since they perfectly retain the taste, smell, and specific virtues of the subject. And as we often call that the essence of a thing, which by its properties makes it known from all others in nature; as mint is distinguished from wormwood, by its peculiar taste and scent, which reside in its oil; hence some chemists call these oils the quintessences, or concentered sulphurs of vegetables. They can be obtained by no other means besides distillation; nor then neither, without the addition of water, (which, by ascending with them, keeps them from growing rancid, and prevents the empyreuma) and the

the use of a refrigeratory to condense them. Which method of distillation being unknown to the antients, they were never acquainted with the great virtues of these essential oils, as we may learn from *Galen*.

7. If these oils are rectified, or briskly distilled over again with fresh water, by the alembic, they become much purer and finer, continually leaving some proportion of earth behind them, and losing a part of their spirit. The water, which thus comes over along with the oil, retains the perfect taste and smell thereof; and at length, after repeated rectifications, becomes so saline as to precipitate a solution of mercury-sublimate. But when this operation is often repeated, the oils lose considerably of their quantity, and grow almost insipid. By distilling ten ounces of the essential oil of aniseeds six and twenty times over, with fresh water, I reduced it to two and a half. And thus if the oil of cinnamon were frequently to be distilled in the same manner, the water that runs off would appear milky, and the oil diminish in its quantity; so that at length, by this means, it would entirely free itself of its spirit, salt, and earth, and be reduced to a very little portion of a fattish substance, resembling wax. After the same manner these oils, being barely shook in water, would resolve themselves into four parts, *viz.* the native spirit of the plant, a salt, which dissolves in the water, a saponaceous substance, or a mixture of oil, and salt, and an earth.

8. These oils being distill'd frequently over, *per se*, in a clean glass retort, seem wholly convertible into mere fixed and insipid earth; for let the operation be repeated ever so often, there will remain at the bottom of the retort some quantity of such an earth. This was first discovered by the excellent Mr. Boyle, who made the experiment with oil of turpentine and oil of aniseeds; and constantly found it to succeed, tho' the distillations were repeated a very great number of times; so that from a pound of his subject, scarce an ounce remain'd unconverted into a pitchy matter, or black earth. This we find deliver'd in that admirable piece of his, where he undertakes to shew, that chemical principles are transmutable into one another. And the like experiments with these have been made at *Paris*, even upon the most rich, precious, and costly aromatic oils of *Asia*. The same thing is also observed by *Helmont*, in his *Aurora Medicina*, of the oil of human blood; which being distill'd a number of times over successively, always leaves a quantity of earth behind it, that cannot be rendered volatile.

9. If our essential oils be distilled off from quick-lime, calcin'd chalk, or the like, for six times running; a pound of them will afford fifteen ounces, or more, of phlegm, or water, and leave not above an ounce of pure oil behind in the retort, as M. *Homborg* has experienced. But the addition in this case being renewed every time, 'tis possible

Processes upon Vegetables.

possible that some small quantity of the phlegm may be afforded by that.

10. When these oils are first lightly digested with alcohol, or a pure and high rectified spirit of wine, and then distill'd again with a very gentle heat, as that of the *Balneum Mariae*; the native spirit, or soul of the plant lodged in it before, which gave the taste and scent to the oil, now rises with the alcohol, and leaves nothing but a resinous, insipid, and scentless body behind. Thus by distilling oil of cinnamon, for instance, with pure spirit of wine, we may bring over all that was specific in the oil, or bark, and gave the peculiar smell and taste whereby each of them was distinguished from other bodies; leaving all the oil untouched at the bottom, in the form of a rosin. And thus we have a method of separating the pure soul of plants from their bodies. We ought not therefore to deride the ancient chemists, when they tell us we are to separate the soul from a subject by menstruums adapted to the work; for in the present case we see that perfect alcohol, which is nothing but a pure, subtile oil, draws to itself the fine specific and aromatic part of the cinnamon, which constituted it the body it was. Which specific part, if we could obtain it alone, without any mixture, might properly be called the essence of the plant. Some of the most judicious chemists have called this spirit the offspring of the sun, on account of the physical cause of its production. And tho' it has been their fortune to be laugh'd at by some men for this; yet herein they spoke with as great accuracy as truth. They justly observed that there are a spirit, and two kinds of oil in plants; the one a glutinous body, which they term'd fixing sulphur, and the other a volatile oil, wherein the spirit of the plant resides, and which is endued with a caustic virtue; for if applied to the tongue, or other part of the body, it burns like fire, but when wash'd in water, loses its acrimony, and becomes innocent. For thus 'tis separated from its spirit, by means whereof it produced such effects, and is turned to an insipid, inodorous oil; whence this spirit may not improperly be called a creature of the sun, or of fire. But farther, the most fiery oils are those which come from the hottest countries; and, indeed, appear to be nothing but a parcel of fire wrapp'd up in a proper unctuous matter, fit to detain it; as hath been render'd probable from some experiments, not long since made in *England*. For some gentlemen of the royal society found, that if a little oil of cloves, or cinnamon, were in ever so cold a place, mix'd with the cold spirit of nitre, they would immediately break out into a flame, which was their aromatic part. And *Helmont*, in his treatise *De Tribus Principiis*, instructs us how to know when plants abound with, and when they are destitute of this oil.

11. After

II. After the same manner, any aromatic essential oil, being long exposed in an open vessel to the free air, will lose its native spirit, and become insipid and scentless, without any considerable loss of weight. Thus a dram of the essential oil of cinnamon, put to cover the bottom of some wide, shallow vessel, would, in a few days time, be deprived of its specific taste and scent, by the air which we suppose to have free access thereto; tho' during that time its diminished weight would scarce be sensible upon the balance. Hence we might be furnished with a method of determining the quantity of this native spirit in the essential oils of vegetables, which, according to *Sandivogius*, is incredibly small, or not more than one part in three thousand and six hundred of the plant. And that this proportion is not rated too high, will appear by the following experiment; which I made on purpose to determine it. From a pound of choice biting cinnamon, I drew all the oil by distillation, after the manner of our present process; and found all that was sunk to the bottom of the water amounted to no more than ten very small drops; as 'tis the nature of this oil not to fall in large ones. Then in order to find how much oil was contained in the milky water that run off along with the former drops; I let some of them fall into a quantity of fresh water, till, upon shaking, it appeared just as milky as the other; and making my calculation accordingly, I found about thirty drops of oil were mixed with the distilled water; so that the whole quantity of oil obtained from my pound of cinnamon was forty drops. In the next place, that I might discover what part of this quantity was owing to the native spirit of the cinnamon, I let fall some drops of the oil upon a glass plate, and exposed them to the air; and found, in a few months time, that they had entirely lost both their smell and taste, so that the remaining part of the drops could not be known from tallow, or any other rancid oil; yet during all this time it had lost only the fortieth part of its original weight: whence we may pretty fairly conclude, that all the native spirit which gave the aromatic virtue to the whole pound of cinnamon, amounted not to above the quantity of a single grain. * It seems to be the office of the remaining part of the oil to preserve and detain this fine, volatile spirit, or reigning principle of the plant; which must needs be of a prodigious force and virtue, since a single drop of the essential oil of cinnamon (only one fortieth part whereof can be this spirit, as we just now saw,) will communicate a rich, aromatic flavour to five pints of wine; or if the same quantity be first mixed with sugar, and so dissolved only in common water, it will make a cordial, which, being drank, surprisingly recruits the

* It appears very difficult to make this experiment with any tolerable accuracy; because at the same time that either fire, air, or spirit of wine, acts upon the oil, so as to deprive it of its native spirit, no inconsiderable quantity of the other volatile parts of the oil will also be ex-

haled, absorbed, or lost. And if due allowance be made for this consumption, we may reduce the animating soul of plants to a very slender bulk indeed; so as to make it seem little more than an *aura*, a *halitus*, or delicate vapor; which is entangled, and fetter'd down by the oil.

Processes upon Vegetables.

animal spirits, and instantly restores the body from a state of languor and depression.

12. When some of these essential oils are kept for any long time in well-closed vessels, they appear to be converted into a kind of salt. This is principally observed of the rich *Asiatic* oils; and I my self have lately seen an instance of it, in a parcel of genuine oil of cinnamon, presented me by a friend, returned from the *East-Indies*; and which had been kept for the space of fourscore years. It was a perfect salt that would dissolve in water, and not a concreted saponaceous substance, as I had formerly been apt to suspect, and have seen instances of. But this is a curiosity which few have been so lucky as to see; for 'tis true, as *M. Homberg* says, that the salt requires a great length of time to form in; and the experiment is not easy to be made shorter. Not to mention that experiments of this kind would require the purse of a prince. *Celsus*, however, obtained a sight of the salt of cinnamon, in the island *Ceylon*, upon opening a vessel full of the oil wherein it was shot: and possibly the ancients had a way of converting this salt of cinnamon, into a stone; which *Helmont* assures us may be done, by a long continued circulation. But this phenomenon is hardly to be expected in the crude, unripened oils of *Europe*.

Physical conclusions from the process.

13. Hence we may observe. (1.) That the taste and scent of plants do not at all depend upon their oils, properly so called, but entirely upon the native spirit residing in them: which being so exceeding small in quantity, gave occasion to *Ludovicus* to call it *Scintilla spiritusosa*, the spark of life. Whence he was of opinion that if we could get it out of a vegetable, pure, and by it self, we should then have the real quintessence thereof; and so by giving a single drop to two of the quintessence of any subject, do as much in the cure of distempers, as we could by giving very large quantities of them in substance. (2.) That the tastes and scents of the waters distilled from vegetables depend upon the same cause; part of the native spirit being mixed with the oil, and detained in them by it. (3.) That there are two kinds of oils in plants; viz. a light one, which is the proper vehicle of the native spirit, and a fixed one, which appears to be the same in all subjects, and serves as a glew to the terrestrial part. (4.) That the oils obtained from vegetables by distillation are such as pre-existed in the subjects. And (5.) That these essential oils may be changed both into earth and water.

Medicinal virtues and uses of the production.

14. All these distill'd essential oils are acrid, hot, inflammatory, refreshing, cardiac, attenuating, and stimulating; upon which accounts they are of admirable use in distempers proceeding from a cold cause, or in the disorders incident to old-age, especially when the body abounds with phlegm; and also in case of intermitting fevers, proceeding from a lentor, and not having their cold fits distinct and regular; in hysteric, hypochondriac, colical, and flatulent cases, from a cold cause; or whenever the nervous fibres, or animal spirits seem torpid, and want to be

be excited. But being highly inflammatory, their use is, by all means, to be avoided in all distempers proceeding from a hot or acrid cause, or even where there is only a suspicion of an inflammation; or the juices of the body are already too much thin'd and dissolved in their texture. Every thing is called acrid, which causes pain when applied to the bare nerves of the body; upon which account it is that we say these essential oils are acrid. They are also hot and inflammatory, because when applied in any considerable quantity to the skin, they excite a great degree of heat, and an actual inflammation attended with pain. Thus a drop of the essential oil of cloves, let lie upon any part, would eat into the flesh, and cause an eschar. And a very moderate quantity of any of them, if drank, wou'd presently inflame the stomach and intestines. These oils are so refreshing, that by being barely smelt to, or tasted, they immediately restore a person from the most languid or depressed state; and prove, when mixed with sugar, and dissolved in water, a noble and instantaneous cordial, reviving or recruiting the animal spirits. They have, moreover, a great attenuating and resolving power, by means whereof they insinuate themselves into any viscid matter, and break or dissolve it away; at the same time that they stimulate and excite the fibres of the nerves and muscles, to discharge and throw it off, when lodged or impacted in them; whence also they raise the spirits, and give a brisk motion to the nervous fluids. For this reason they cannot but be highly proper in all distempers from a cold cause, where the circulation is languid, and the juices viscid. But besides these general properties, of which all the essential oils of vegetables partake, they have all something peculiar to themselves, as containing the specific virtues of the plants; so far as these are discoverable by our senses. Thus the essential oil of mint, for instance, acts in the body by the general properties of all essential oils, and also by those which are peculiar to it self, and distinguish it from the oils of other vegetables. And upon those two principles of action depend all the virtues of plants. Thus the oil of savin is peculiarly adapted to provoke the menstrual flux, when obstructed by any viscid cause, and a want of force in the circulation. The like is also proper in any viscid or cold disorders of the *uterus*, being taken in the quantity of three or four drops in sugar, or any proper vehicle; which is a medicine that will also forward and promote the exclusion of the *fœtus*, when the delivery is retarded by any cold cause, or weakness on the side of the mother: but it ought only to be given where there is a want of strength; otherwise it might do mischief, by stimulating too much. The essential oil of rue is good against the epilepsy, when it proceeds from a relaxation of the nerves; that of mint, for a weak and cold stomach, and to stop a vomiting; that of juniper against the cold scurvy, and the nephritic pains proceeding from it; that of lavender, in case of convulsions, the falling-sickness, the palsy, vertigo, weak nerves, and all cold disorders of the

L 2

head;

Processes upon Vegetables.

head; that of fennel for cold flatulencies in the stomach and intestines, or when they are weak and unable to perform their office: the oils of tansey, wormwood, and the lesser centory are powerful remedies, and almost specific for worms in the body; oil of roses excellently refreshes the languid spirits; oil of citron-peel prevails against the palpitation of the heart; oil of baulm against melancholy, proceeding from a cold cause; and the essential oil of cinnamon is a noble hysseric; and in fainting-fits, from want of motion in the spirits, a most powerful cordial.

PROCESS XXIII.

Exhibiting the manner of distilling Essential OILS, per vesicam, from the Flowers of vegetables; by an example in Camomile-Flowers.

The process.

1. **L**ET fine camomile-flowers, fully ripe, gathered early in the morning, and gently dried in the shade, stand in digestion, with a sufficient quantity of pure rain-water to cover them, for the space of four and twenty hours; and afterwards proceed to distillation, in the manner of the preceding process. That which runs off first will be a water, retaining the perfect rank smell and taste of the flowers: then follows a water impregnated with a fine azure oil; and at length, if the distillation be continued, a clear or acid liquor; which is by no means to be mixed with the former. (2.) Now strongly press out the decoction from the flowers, and pour it back, together with all the odorous water and oil that was before distilled off, upon fresh flowers; adding also, if there be occasion, a little more rain-water. Suffer all to digest for twenty-four hours more; and then distil off the water and oil, as before. And by this means, if the operation be frequently repeated, you may at length obtain a very large quantity of oil, in a high degree possessed of the taste, scent and virtues of the flowers.

*How perform-
able to advan-
sage.*

2. The native spirit of plants generally seems to reside in no part so much as in their flowers; for which reason they ought to be gathered and dry'd with great caution for this operation. But there are some of them, which tho' they prove exceedingly odoriferous, yet afford but a very small quantity of essential oil, by distillation, unless they are for a long time first digested with water, made sharp by spirit of vitriol, spirit of salt, or the like. And, indeed, we constantly observe, that the more odoriferous any flower is, or the more native spirit it contains, the less essential oil it affords; as is evident in jasmin-flowers, lilies, &c. Thus the oil of damask roses, on account of its scarcity, and the great labour and expense required to obtain it, was formerly sold as dear as gold; and even esteemed by some people as a non-entury. But M. Homberg has shewn us, that if such roses be digested for a month in acidulated water, they will afford a very considerable proportion of oil; tho' otherwise a large parcel of them would yield scarce any at all by distillation. 'Tis very observable, that the essential oils of plants differ in their

their colour, with the nature of the subject; thus the oil of our present process is of a fine blue or azure; that of wormwood, green; that of mint, yellow, or gold-coloured; that of lemon-peel pale, &c.

3. The medicinal virtues of our oil of camomile are carminative, and anti-colical, which render it serviceable in flatulent cases; and if it be mixed with the extract prepared from the remaining decoction, after the distillation is over, it affords a medicine for agues or intermitting fevers, scarce inferior to the *Peruvian bark*; being endowed with an admirable diaphoretic and resolving quality. A dram of the extract, mix'd up with two or three drops of the oil, may be given two or three hours before the fit is expected, in order to prevent it: or, otherwise, we may exhibit it after the same manner as the bark.

P R O C E S S XXIV.

Exhibiting the manner of distilling Essential OILS from SEEDS and BERRIES, per vesicam; by an Example in FENNEL-SEED.

I. **T**AKE fennel-seed, gathered on a clear day, when fully ripe, and carefully dry'd in the shade, and set it to digest for fourteen days in so much rain-water, acidulated with oil of vitriol, or made saline with common salt, that it may commodiously swim about therein; and afterwards distil off the water, exactly in the manner directed above; and the oil will come away along with it: but observe to let the fire be gentle at the first.

2. All manner of aromatic seeds and berries are proper subjects for this process; such as cummin-seed, aniseed, juniper-berries, &c. which will afford a very large proportion of oil: whence it appears that these parts of vegetables are very oleaginous and unctuous. And this gives us to see the reason, why the seeds of vegetables are capable of remaining perfect in their taste and scent, and fit for vegetation, during so long a season as we find they do, when guarded from too great a quantity of moisture and heat. For the large quantity of oil they contain, defends the embryo from all the violence and injuries it would otherwise receive from the air or water, with whatever is contained therein. Every seed contains a little seminal plant, or embryo in the middle, between its two lobes, which serve as a *placenta uterina*, and contain little vesicles of oil to defend and preserve it; but when once any moisture comes to penetrate these lobes, the seminal plant begins to shoot and grow; but whilst these lobes remain dry, or unaffected by the moisture, whether of the air or earth, they defend the embryo, as trees are kept from the winter's cold, by the oil which is then plentifully lodged in their bark. But when any seed comes to be steeped in water, the moisture gets into it,

rari-

Processes upon Vegetables.

rarifies the oil, and causes the seed to swell, open, cleave into two parts, and then the oil is gradually consumed, or drained out of its cells. And if at this, or any other time, the seed should be deprived of its native or presiding spirit, 'twould no longer be fit for vegetation. Thus if any seed be once put to soak in water, and afterwards dry'd, then soak'd again, and committed to the ground, it will never shoot, but dye and moulder away; because, by this means the native spirit, which shou'd give motion to all its parts, having been set loose from the oil, is now flown off. But by keeping vegetable seeds in a dry place, this effect will be prevented: and thus some kinds of grain may be preserved in a state of perfection for ten, twenty, or thirty years, and still be fit to grow again, when sown. And hence also we may see a reason why fruits should be endowed with a certain proportion of oil, as we find they are.

*With what
caution to be
performed.*

3. In distilling off the oils from some seeds, as particularly those of anise, caraway, daucus, &c. after the manner of our present process, we find the oil apt to stick in the worm, and clog it up with a thick concreted matter; to prevent which 'tis necessary to leave the worm for some depth uncovered with the water of the refrigeratory, that the heat thereof may melt the oil, and carry it down into the receiving vessel below. Or if that be not sufficient, we must dissolve the coagulated matter, by running hot water thro' the worm. This concreted matter, or oil, is, in reality, no other than the camphire of the seeds; for camphire is not peculiar to any one tree or vegetable; but all aromatic plants produce their camphire, which is only the native oil, by length of time concreted and hardened into a white, fat, transparent mass, called by that name. Thus the oil of several plants in the island Ceylon, and particularly that which distils from the cardamom-seed, is almost wholly converted into camphire. And this may serve to shew us, that our essential oils must needs be very rich in their nature, as greatly participating of the aromatic parts of vegetables; and being, in reality, but a fluid kind of camphire.

PROCESS XXV.

*Exhibiting the manner of obtaining Native OILS from the
rich and hot spices of India; by the treatment of Indian
CLOVES.*

The process.

1. **D**igest entire Indian cloves, that have never been robb'd of their native oil, in twenty times their own quantity of rain-water, for the space of four and twenty hours; then commit them to the alembic, and proceed as in the preceding processes, and there will run off a thick, milky, odoriferous, and aromatic water, of a fiery taste, and containing a very large proportion of oil, which will

will sink to the bottom of the water, and prove so intolerably hot and fiery, as not safely to be touched with the tongue. (2.) When the hot aromatic water seems to be all run off, pour fresh upon the remainder, and repeat the distillation, to draw all the oil out of the subject; and at last there will run off a clear, acid liquor, very different from the former, which is to be kept separate by it self.

2. The vegetables which grow in the hottest countries are always of the most aromatic and fiery nature, and afford the heaviest and hottest oils by distillation. Thus the essential oils of cinnamon, *Winter's-bark*, galangal, pepper, cardamoms, ginger, &c. seem to be concentrated fire; for when applied to the skin of the human body, they burn like a caustic. But among all the aromatic productions of the *Indies*, none seems to abound more in oil than cloves; for which reason they require the greater quantity of water in their distillation. But they seldom come to us, till they have been deprived of their oil; the best part whereof is commonly drawn from them in the *Indies*; after which they are, perhaps, mixed up with some that are better, which communicate to them their smell and taste, and make them appear as we commonly find them: but naturally they are so very unctuous, that their oil may be express'd, and made to drop from them by the fingers. Nor does any oil appear to be of a more fiery nature than this of cloves; for if mix'd with twice its own quantity of spirit of nitre, it will turn to flame in an instant. And by being barely kept for a few days in the open air, it loses all its hot, aromatic virtue; and the remainder becomes rough and unactive. The high price at which both this and other aromatic oils of the *Indies* are sold, frequently occasions them to be adulterated with oil of almonds, or the like; but the cheat may easily be discovered, by the want of their due specific gravity, or their slow descent in water.

3. The cloves which remain after this process is perform'd, appear to have lost all their taste and scent, but when soak'd in fresh water, swell and recover their natural bulk; which gives occasion to their being sometimes sold so cheap at *Amsterdam*: for 'tis very easy to throw a parcel of fresh cloves among those which have thus been robb'd of their oil, and put them off for genuine.

4. This oil made into an *elæosaccharum*, and mixed with wine or water, affords an admirable remedy for women in labour; or in case of languor and faintness during the time of their lying-in: 'tis also of very great service to alleviate, or put by the fit of an intermitting fever.

*Medicinal uses
of the produc-
tion.*

PROCESS XXVI.

Exhibiting the manner of distilling Essential OILS from the Barks of Vegetables; by an example in CINNAMON.

The process.

1. **T**O a proper quantity of strong, fresh, fragrant, weighty and biting cinnamon, broke into small pieces, pour ten or twelve times its own quantity of the distilled water of cinnamon, acidulated with spirit of vitriol, and proceed immediately to distillation, as in the former cases; and there will run off a very thick and white odoriferous water, which, being received in a pure vessel, will deposit an oil of a golden colour, and of an exceeding pungent and fiery taste. (2.) Pour fresh boiling water frequently upon the remains, to prevent any empyreuma, and to bring off the whole quantity of the oil: and continue doing thus, till the clear, insipid or acid liquor begins to come; which is so apt to corrode the still-head, and thereby gain an emetic quality. The oil will be found only in a small quantity; the distilled water being very richly impregnated with the rest*.

*How perform-
able to advan-
tage.*

2. If you would increase the quantity of your oil, add a large proportion of salt, or oil of vitriol to the water first poured upon the subject; for such an addition has the power to volatilize vegetable oils:† and let all the water made use of be what has already been distilled from cinnamon, and retains the perfect scent and taste thereof. Those barks which even in the cold prove odoriferous and volatile, need no previous digestion; but may directly be submitted to the operation; as the bark of sassafras; for instance, and our present subject cinnamon: for a long digestion would rather consume than preserve their volatile oil. But all the barks to be distilled for their oil, should be taken from the boughs, or near the roots of old trees, during the autumn, or the beginning of winter; for then the bark abounds most with gum, rosin, or balsam: but in hot countries the wood often contains as much oil as the bark. When the bark of any tree proves hard, being first carefully dry'd, it may be shaved, or reduced to a gross kind of powder, and digested in salt-water, to make it afford its oil to greater advantage; by which means it may be brought to yield a larger quantity than the wood of the same tree, and appears possessed of greater virtues.

4. The remains of our subject, after distillation, no longer retain the least smell or taste peculiar to cinnamon, but are now as austere and scentless, as if they were the bark of an oak: they retain, indeed, their own na-

* Glauber has a way of obtaining the rich and costly vegetable oils, to profit, with spirit of salt alone; which he pours upon the subject, and distils in a sand heat; all the oil thus commodiously rising along with the aque-

ous or phlegmy part of the spirit; from which it may readily be separated, without loss.

† It also seems to mix with them, and somewhat alter their natural flavour.

tural

tural form, but nothing more. Yet even this property, when cunningly made use of, will turn to advantage; for cinnamon, thus treated, may be dried and mixed among some that was never submitted to distillation, or but in a small degree; and so be sold undiscovered in large parcels.

The essential oil of cinnamon is exceeding strong and fiery; a single drop of it being enough to burn the tongue, and cause a gangrene. *Medicinal virtues and uses of the production.* A servant-maid being once set to look after some of this oil, as it stood over the fire, unluckily clapp'd a little of it to her mouth, with the end of her finger, as it happened to run down the side of the vessel; which immediately burnt her lips, jaws, and all the parts of her mouth, like fire; whence a gangrene presently followed, and in two days after, notwithstanding all the means that could be used to prevent it, death. But when this oil is properly used, or mix'd with sugar, and so diluted in wine or water, 'tis a most admirable cordial; at once both warming the body, and raising the spirits. Not only the oil, but also the first running of the water affords an incomparable remedy in all the cases peculiar to women; and especially where the person is of a cold constitution.

P R O C E S S XXVII.

Exhibiting the manner of distilling Essential OILS from WOODS; by an example in SASSAFRAS.

1. **R**educe sassafras-wood to chips, or shavings, pour thereon a sufficient quantity of rain-water; and immediately proceed to distillation, as in the case of barks or seeds. *The process.*

2. Those woods, which are very aromatic, and easily yield their oil, especially if they be light and spongy, such as our present subject, need only be shaved thin, and put to the water, in order to prepare them for distillation. But those which are solid, close, dry, and heavy, such as *lignum aloes, lignum vitæ, rhodium, lignum ferri, Indian cedar*, (from whence drops myrrh, and the balsam capivi) the cedar of Lebanon, box, snake-wood, &c. ought to be very long digested in salt-water, or water impregnated with a considerable proportion of some acid spirit, and that in vessels well closed, to loosen the oil, and make it ready to ascend by distillation. The space of several weeks is sometimes requisite to prepare the subjects for this operation. Thus, if that heavy wood rhodium, which affords so sweet an oil, or balsam, were to be boiled ever so long, and a water distilled from it, a very inconsiderable quantity of oil would be thereby gained; till once its body was unlock'd and open'd by a previous, and long-continued digestion. But when ground to a coarse kind of powder, and put to steep for the space

M of

Processes upon Vegetables.

of two months, with a proper quantity of acidulated water, in very close vessels, it will copiously give out its incomparable oil in distillation. Any of these solid and ponderous subjects being thus prepared, and distilled in the same manner as was formerly said of seeds, will freely afford their oil, tho' in a less proportion than those; but generally in the greater plenty, as they are more odorous, and of greater specific gravity, with respect to one another.

*What subjects
are best fitted
for it.*

3. All those woods which contain any quantity of turpentine, rosin, gum, or unctuous matter, are proper subjects for this process; but those which shoot apace, or grow in damp or watery places, as the willow, the lime-tree, the poplar, &c. are very unfit for it; being soft and spongy, and affording but a very small quantity of oil. The trees which grow between the tropics are generally fit to distil for oil, which proves so heavy as to sink in water, and render the liquor they afford in distillation exceeding white and milky. And, in general, the heavier and more dense the woods are, the more oil they afford by the treatment of our present process; and the more porous, brittle and crumbly they become, after they have once undergone it. The wood of those trees which is cut when they are grown old, as also that fell'd whilst they were very young, or in the spring-season, gives but a small proportion of a less perfect oil, by distillation; in comparison of what that does which was cut in the first of the winter, from a middle-aged tree, and afterwards gently dried.

*The physical
doctrine is af-
forded.*

4. And this may give us to understand whence the weight, durability, hardness, native balsams, and rottenness of wood proceed. The gravity of any wood is, without dispute, proportionable to the quantity of oil it contains. Thus *lignum vita*, that naturally sinks in water, will float thereon after its oil is extracted by distillation; whilst the oil itself will presently fall to the bottom. And 'tis a general rule, that the least oily woods are always the lightest; and *vice versa*. The oil of vegetables, therefore, appears to be their heaviest part. All the woods that are durable, contain a large proportion of oil; but those which cannot long remain uncorrupted, a small one. Thus any utensils made of the lime-tree, for instance, which greatly abounds with water, and but little with oil, will scarce last longer than a year; whilst those of guaiacum, cedar, &c. which are copiously stock'd with oil, hardly sustain any damage by time. Whence the antients chose to build their ships of cedar. The more any wood is filled and swelled with oil, the harder it constantly proves; of which we may have a plain instance in the *lignum vita*, by comparing two pieces of different ages together; for the oil turning to a kind of gum, or strong stinky matter in the older, keeps all its parts firmly connected together, and renders the whole body of it compact and solid. Whence its essential oil is obtain'd with difficulty; and proves too hot and fiery to be used in medicine, without a deal of caution. The native balsam of
woods,

woods, or that which sweats spontaneously from the growing tree, and afterwards assumes the form of a rosin, gum or pitch, is nothing but the oil of the vegetable, made to flow out of its subject by the heat of the sun, which then condenses, and fixes it into a more solid form. Wood is subject to two different kinds of rottenness; that from the worm, and that from a loss of its oil by exhalation. The worm, whose body and proboscis are both exceeding soft and tender, has a surprising power of piercing the hardest wood; where, feeding upon the oil lodged in the cells, it gradually reduces the remaining part to powder. Length of time gives an opportunity to the sun, the air, and other causes to act upon the substance of wood, and by degrees exhale its oil and volatile parts, so as at last to leave only a soft, crumbly substance behind, as we see in that rotten wood which has a luminous property; or else into a kind of ashes, as if the subject had been calcined by the fire. And both these species of rottenness are observed to affect such woods the soonest, as least abound with oil; such are elder, willow, &c.

5. Hence we see, that the wood designed for fuel, and all mechanical and medicinal uses, the building of ships, &c. ought to be cut in the winter-season. All timber-merchants are acquainted with this; and accordingly, when they require wood in its perfection, and fit for service, they have it brought from the coldest regions, where the trees contain a greater quantity of oil, than in such as are hotter, or high montaneous places, which are always cold. The larger proportion of salt or water any wood contains, the more unfit it is for the uses of the ship-wright, or architect; and therefore they never chuse to cut it in the summer, or the spring, when trees are chiefly saline and aqueous; but either in autumn, when yet there is some quantity of water adhering to the oil, or in the beginning of the winter, when the pure oil is condensed by the cold, and compacted with the wood, to defend the body of the trees from the frost. *Its physical and medicinal uses.*

6. Having seen how oils are obtainable from vegetables by expression, emulsion, coction, and distillation with water, we are next to shew the method of obtaining them pure, as they exist in their several subjects, without any mixture of water, and by no greater degree of heat than that which makes them sweat or distil from the tree. *Introduction to the next process.*

PROCESS XXVIII.

Exhibiting the manner of distilling the pure native OILS of Vegetables, per descensum; by an example in INDIAN CLOVES.

The process.

1. **L**ET fine, fresh, ripe, and unctuous cloves be lightly bruised, put into a clean linen cloth, and suspended, for some time, in the vapor of hot water, to soften and open them, so that they may the more readily give out their oil; then accommodate and fasten the extremities of the containing cloth, to the edge or rim of a deep glass vessel, and fit it with a concave cover of iron, and lute the juncture. Then in the hollow part of the metalline cover, strew fine sifted ashes, and place upon them a few live coals, that may gradually heat the spice all round, and cause its liquid parts to drop through the strainer, to the bottom of the containing vessel. An aqueous-vapour will first descend, and appear in the form of water, retaining the perfect smell and taste of the cloves; and afterwards a small quantity of fine and excellent essential oil, which may be increased by augmenting the fire; but then there will be danger of giving an empyreumatical, or burnt smell and taste thereto.

*How perform-
able to advan-
tage.*

2. All the aromatic and oily parts of vegetables are proper subjects for this process; such as cinnamon, mace, nutmegs, ginger, pepper, the roots of zedoary, galangal, angelica, master-wort, orange-peel, citron-peel, &c. which being gather'd when fully ripe, gently dried, bruised, and treated as above described, will afford a set of essential oils, which may at any time be expeditiously prepared, with little trouble and great advantage; these oils being little inferior in virtues to those acquired by distillation, *per vesicam*; only for want of water, they are apt to prove empyreumatical; unless the fire be very cautiously regulated: which inconvenience is easily avoided in the other case. And after the same manner is pitch and colophony obtain'd in large quantities from vegetables, *per descensum*; viz. by placing proper parcels of fir-wood, for instance, upon a grate, and lighting a fire above, which drives their rosin or gum downwards into the vessel below.

*Corollaries
from the history
of vegetable
oils.*

3. We may learn from the several preceding methods of obtaining the oils from vegetables, (1.) What their aromatic virtues properly are, and wherein they consist. The aromatic virtue of a plant appears to be some infinitely small quantity of matter, which we call its native spirit, lodged in the peculiar oil thereof. The oil itself is not the aromatic part of the vegetable; for the native spirit may be perfectly separated from that, which will then be left entirely destitute of its particular taste, smell, and specific virtues. And hence the expressed oils of spices are not so aromatic as those they afford by distillation. The expressed

press'd oil of nutmegs is like wax, and without that strong scent and taste, so predominant in the essential oil. 'Tis the quantity of this presiding spirit that sets the difference betwixt the hot aromatic plants and the cold ones. Thus sorrel and kali contain so little of it, that it seems lost therein, or swallowed up by the abundance of acid salt, with which they abound. But such plants are called aromatic, wherein the native spirit is so little obscured, that it appears to be the predominating principle. There have been those who pretended that this aromatic spirit was owing to the salt of vegetables; but in reality, that seems to have little or nothing to do with it; because there are several plants which greatly abound in salt, yet have no aromatic virtue at all. (2.) What manner of action the sun exerts upon aromatic vegetables. The common action of the sun upon vegetables dissipates their aqueous parts, renders their salts volatile, dissolves their oil, and at length leaves little in them except their glutinous or fixed oil, and earth. But besides this general action of the sun, it appears to have the power of generating this aromatic or presiding spirit in plants; for this is never found where there is no fire; and always in the greatest plenty in the hottest climates. It may, indeed, reside in the seminal principle of the plant; but 'tis always cherish'd, brought forwards, and increased by the heat of the sun. There are few aromatic plants to be found near the north pole; but they grow plentifully, and in very great perfection, in the hot, southern climates. (3.) Whence the balsams, resins, gums, and tears or droppings of trees proceed. For the essential oil of vegetables being prepared from their nutriment, and lodged in proper cells during the winter season; when the warm weather comes on, it is agitated, rarified, heated, made to burst its cells, and sweat out at the bark in form of an oil or balsam, which afterwards hardens into lumps of resin, or gum, of particular shapes and sizes, according to the nature of the subject, its juices, and the quantity that comes out at once: whence we are furnished with camphire, storax, benjamin, labdanum, &c.

4. We now proceed to shew how many different kinds of substances are obtainable from one and the same vegetable by distillation, without the assistance of water. And to accomplish this, we shall make choice of two subjects of different classes, under one or the other whereof all vegetables may, so far as my experiments reach, which were carefully made with this view, be commodiously ranged. The first is that of those which afford a volatile, oleaginous, acid salt in distillation; and the other of such as, contrary to the common opinion of chemists, yield a volatile, alkaline, oleaginous spirit by the same means. A general example of the former will be afforded us by *lignum vita*, and of the latter by mustard-seed.

PROCESS XXIX.

Exhibiting the method of analysing, or resolving dry, acid VEGETABLES, per se, into their several component parts, viz. a Water, two kinds of Oil, a Vinegar, and a Coal; by an example in Lignum Vitæ.

The process.

1. **F**ILL a glass retort almost to its neck, with the chips or dry shavings of guaiacum wood; apply a large receiver to the retort, lute the juncture with the common mixture of linseed-meal and water, and begin the distillation in a sand furnace, with a very gentle fire; augmenting it, by degrees, up to the strongest that can there be given: and thus there will be obtained, (1.) A large quantity of a clear aqueous liquor, or water. (2.) A red, and perfectly acid liquor, or spirit, tho' mixed with oil, and retaining something of an empyreumatical taste and smell. (3.) A light red oil, that will float on the top of the former water, or spirit. (4.) With a fire of suppression, that is, live coals being placed all around the retort, on the top of the sand, and the fire below raised to its highest degree, so as to make the sand glow; there will come over a ponderous, acid spirit, together with a black, thick, heavy, pitchy oil, that sinks to the bottom of all the former liquors. And, lastly, how great soever the fire be now made, there will remain behind a black, inodorous coal, (retaining about three parts in four of the original weight of the wood,) which, when applied to the fire, in the open air, flames and consumes away to insipid ashes.

With what cautions to be perform'd.

2. The fire, at the first, should be no greater, than that one drop of the water may follow another, at such a distance of time as will allow us to count twenty; and this degree is not then to be increased, unless the distillation intirely ceases. The first increase that is made should only hasten the drops, so that ten may be counted in the space between their falling one after another; and thus we are to proceed gradually, till at last, by a fire suppression, the retort be made red-hot.

The doctrine it affords.

3. The acid spirit, which ascends along with both the oils, may be separated from them by the filtre; and the oils, left behind, be purified by the mixture of water, with which all acids readily unite. By this means the two oils may be brought together, and both the acid spirits united into one. If the vinegar, or volatile and acid spirit, thus distill'd and separated, be pour'd upon chalk, it strongly boils up therewith, and dissolves it; and if distill'd off from it, affords almost an equal quantity of an insipid water, with a large proportion of transparent oil floating thereon, which has now lost its red colour, wherewith it tinged the spirit, behind in the chalk. But the chalk is only thus colour'd in its superficial parts; because, tho' the acid is readily drank into the pores

pores of that body, any thing which is unctuous cannot so easily pass them, and therefore remains upon the surface. 'Tis the oil which thus tinges the spirit red ; for if they are suffer'd to stand for any long time together, the oil will fall to the bottom, and leave the spirit above it limpid. Hence it appears, that oil and acid salts exist in vegetables, in the form of a soap ; and that there are acid, oleaginous soaps, as well as those which are alkaline and unctuous. And this is the reason of the great medicinal virtues of these acid spirits : 'tis their saponaceous nature that renders them so sudorific, diuretic and penetrating, absterfiv, stimulat-ing, and resolving, as we find them ; whence Mr. Boyle, and others, pre-scribe them in the quantity of a dram, when any extraordinary motion is to be excited in the body. Indeed, they are excellent sudorifics in pestilential cases : and Paracelsus declares, that an ounce of this spirit of guaiacum will have a greater effect in the venereal distemper than a pound of the wood, used in the way of decoction ; but I have never made the experiment. Hence we also see what a small quantity of latent acid there is in vegetables ; since the chalk here employ'd, is very little aug-mented in its weight, by all that it drank in thereof. Yet this was suf-ficient to keep the oil mix'd with the water in the form of an acid spi-rit ; for when separated, or detained in the chalk, the oil was set loose, and floated freely on the surface of the water.

4. The oil which first rises in the operation, is light and volatile, ^{Nature of the} and approaches in its virtues to those obtained by distillation with wa-^{first oil.} ter, especially if it be once rectified or distill'd off in the same manner as they ; for by this means it will be separated from its acid and and gross part, and come over clear, thin, subtile, and of a beautiful red colour, without any disagreeable empyreuma. Or the same end may be obtained, by distilling off this oil from a fix'd alkali.

5. The thick, heavy oil, made to ascend at last by a very violent fire, ^{Nature of the} sticks like pitch to the bottom of the receiver ; and is more fetid and caustic^{second oil.} than the former. The stronger fire has impress'd an empyreuma upon it ; and the adhering salts have render'd it sharp and corrosive. But by being rectified, *per se*, or with water, it loses of its ill scent, and grows more mild and fluid, and comes nearer up to the nature of the first oil ; from which it only differ'd on account of the greater change brought upon it by the fire, and its consequent participation of more princi-ples of the subject.

6. Hence we see, (1.) The tenacious or glutinous nature of water ; ^{Physical uses of} which adheres so closely to plants, as not to be discovered in them after^{the process.} they are dry, till they come to be expos'd to the fire. If guaiacum, or any other durable wood, were kept for twenty years, or longer, and then distilled, it would afford a considerable quantity of water ; tho' be-fore the operation it appears to be absolutely dry, and as hard as iron. Whence it should seem, that water is necessary to be mix'd with the other principles of vegetables, in order to their preservation ; and that

Processes upon Vegetables.

to separate it from them, would tend to the destruction of the whole concrete. (2.) The nature of the acid latent in vegetables; whose office it appears to be to preserve them from corruption, and the worm, and render them firm and durable; to which end it is made strongly to adhere to their oil, which prevents it from flying off. For if any wood, containing but a small proportion of oil, be kept for several years, and afterwards distill'd, it will afford no acid spirit. This acid of vegetables differs from their fix'd alkali, as being generally more volatile than that saline matter which affords it. Thus recent *lignum vite* affords a large quantity of acid by distillation, and afterwards its fix'd salt by calcination; but some plants yield a volatile alkali first, and leave no fix'd salt behind. (3.) The nature and matter of smoke and soot, which are only the more volatile parts of the fuel, or the water, essential oil, and acid spirit of vegetables, made to ascend together in vapor or fume, and afterwards condensed into a light, soft, black, spongy matter, of great medicinal virtues, and affording a fine volatile salt by distillation. Whence we learn how the sharp smoke of wood comes so greatly to affect the eyes and lungs. (4.) The reason of the method of drying and preserving the flesh of animals by smoke. For the acid salt of the fuel employ'd in the operation, being thus made to insinuate into the pores of the subject, it prevents their corrupting; and, according to its own nature, turns them of a red colour; whence those herrings, or other fish treated in this manner, are supposed to be the best cured, which appear the reddest. (5.) The seat and cells of the oil, the water, and the spirit in vegetables; which appear to the eye, by examining the coal. (6.) The nature and properties of *Helmont's* everlasting coal. *Helmont* pretends to a wonderful secret, so as to make a coal keep burning for ever, in the midst of a most violent fire, without appearing to be at all consumed; but, in reality, his method is no other than that of our present process; whereby the remains of the subject may be kept ignited, without burning out, till air be let in upon them. And tho' this has been thought a ridiculous paradox in *Helmont*; yet I myself have, for the space of three days and three nights, kept such a coal, constantly urged with a very strong fire of suppression; after which it has still remained black and unconsumed; tho' the least spark applied to it in the open air, would instantly make it burn out, and reduce it to ashes, which, unless the subject were green, would be almost insipid.

PROCESS XXX.

Exhibiting the manner of resolving dry, alkaline VEGETABLES, per se, into their component parts; viz. a Water, a Spirit, two kinds of OIL, an alkaline, volatile Salt, and a Coal; in the treatment of MUSTARD-SEED.

1. **FILL** a glass retort, almost up to the neck, with fresh, strong and ripe mustard-seed, that has been gently dried; and cautiously proceed to distillation in a sand-bath, with the same degrees of fire, as in the last process. Then there will come over, (1.) An acrid, fetid water, of a peculiar empyreumatic and cadaverous taste and smell; but neither acid nor unctuous. (2.) An unctuous spirit, perfectly resembling that of human blood, with a light yellow oil that floats upon its surface. (3.) With a fire of suppression, white fumes arise, which condense into a white, volatile, crystalline salt, like that of harts-horn, on the sides of the receiver. (4.) A thick, pitchy, resinous oil, that sinks thro' the other liquors to the bottom of the retort. (5.) A coal remains behind, as in the preceding process; which affords no fixed salt by calcination; but if farther urged with the fire, in the same close vessel, it becomes a fit matter for the making of phosphorus; tho' it affords a less proportion thereof than urine. The process.

2. If the spirit which came over second, be again distilled with a gentle heat, it will yield a copious, volatile, alkaline or urinous salt, like that of animal substances. And as for the oils, they may be separated and purified, as those in the last process; but instead of an acid, an alkaline salt will here constantly be found mix'd with them. That such salts should be obtainable from vegetables, without putrefaction, has been accounted a great paradox; as the way of doing it remain'd unknown to *Helmont*, and many other excellent chemists. And there are still some who pretend, that there is a certain fix'd salt in vegetables, which may be changed into an alkali by putrefaction; but absolutely deny that a volatile salt naturally exists in plants. *Wedelius* first taught how to obtain this volatile salt by putrefaction; but if we proceed in the manner of Mr. *Boyle*, which is that of our present process, we may readily obtain them from the proper subjects without it. Mr. *Boyle* was the first, that I know of, who obtained it from mustard-seed; as I myself have done from *Euphorbium*. But, indeed, it may be obtained by the bare action of the fire, without any putrefaction, from all the antiscorbutic plants, or those of the mustard, acrimonious, hot, or biting kind, which, by their effluvia affect the eyes, the nose, and irritate the parts so as to cause involuntary tears; such are onions, squills, garlic, leeks, horse-radish, scurvy-grass, cresses, hedge-mustard- Its nature and proper subjects.

mustard, rocket, the sparges, euphorbium, and, perhaps, all the poisonous plants of *Africa*, when fully ripe, well dried, and in their perfection.

Medicinal uses
of the produc-
tion.

3. The volatile spirit and salt of our present process, are very heating, penetrating, aperitive, and approaching to a caustic nature, or that of fixed alkalies, but of contrary properties to acids. This makes them exceeding useful in medicine, where they supply the place of animal spirits and salts, as those of harts-horn, urine, &c. in all cases where the active principles of the body are languid; but not so where oils or salts already abound. Thus they are serviceable in phlegmatic constitutions, or the scurvy proceeding from an acid cause; as acids are in that which proceeds from a predominating alkali; in case of a lentor in the blood and juices, which prevent, or retard the digestion of the aliment, or its conversion into blood; and in small obstructions, or other cases where there are no signs that the humors are already of too alkaline a nature; which may be known by a fetid breath, a scrophulous constitution, the corruption and putrefaction of any part of the body, or an universal factor; in all which cases, acids are the remedies required.

Medicinal uses
of the process.

4. Hence we have a just foundation for distinguishing all vegetables into two different classes; viz. those which yield a volatile acid, and such as afford a volatile alkali, by distillation; which distinction is absolutely requisite to our making a right use of the vegetable part of the *matéria medica*, and employing it with any tolerable advantage, or safety in the practice of physic. All the plants which afford a volatile alkaline salt, are properly prescribed in cold, pituitous cases, where a fretting, corrupting acid, or muriatic salt abounds; but where the bile is too acrimonious, or the texture of the blood too much dissolved and broke, or disposed to putrefaction, they are by no means to be used. On the other hand, those herbs which afford an acid salt in distillation, are properly ordered in all putrid or pestilential cases; and what is something surprizing, even the venereal disease is best cured by acid vegetables, such as the woods of sassafras, guaiacum, box and juniper; but rendered worse by alkalies: so that I cannot agree with those, who would have the specific cause of it to be an acid. I once had a patient ill of this distemper, in whom I was obliged to make use of vinegar and oil of vitriol, to prevent an universal putrefaction.

PROCESS XXXI.

Exhibiting the four ways of separating distill'd OILS from the'r water, vinegar, salt, and spirit; viz. by the filtre, decantation, or inclination, absorpsion, and the separatory; with the method of purifying, preserving, and converting them into ROSIN.

1. **C**UT a piece of thin cap-paper into the form of a concave cone, moisten it The process. with warm water, and place it in a glass funnel; then if a mixture of water, vinegar, or spirit, and oil, be poured into it together, all the former will pass through, and leave the oil behind; provided the paper be not suffered to dry, and the operation be stopped when the rest are run off. But if the paper were moisten'd in oil, then the oil itself wou'd first come through, and leave the water, spirit and vinegar behind. And this is the method of separating oils by the filtre; which we employ only when the oils are not very costly; because of the waste. (2.) When the oil to be separated is costly, but so light as to float on water, pour the mixture into a bellied glass, with a long and slender neck, and of such a size, that the liquor may perfectly fill it; then plunge the vessel in warm water, to dissolve or liquify the oil, and make it all rise to the top; so that by gently inclining the glass, it may be poured off pure from the other liquors into a vial; but if any oil still remains behind in the glass, pour hot water into it, whereby the oil will be made to ascend to the neck; and thus it may be separated, even to the last drop. (3.) When the rich oil is heavy and sinks in water, let the other fluids be first grossly pour'd off from it; then fill a bellied vial, that has a slender neck, with the oil and the liquor that adheres thereto, and place it in some warm water, to dissolve the oil from the sides of the vessel; by which means, also, the lighter parts of the mixture will be forced from it, and swim upon the surface thereof, so that it may easily be imbibed, and clean taken off, by degrees, with a wreath of paper, first moistened in water, and squeezed out at every time, so as to leave the oil pure, in the belly of the glass. (4.) Or else, in general, we may make use of the separatory, which is a bellied glass, that rises with a narrow neck, but descends in a slenderer, conical tube, perforated at the end; into which the mixture being poured, the oil will settle at the top, if it be light, or fall to the bottom, if it be heavy. In the former case it may be decanted, or else the lighter parts being suffered to run off from it, the oil at length may be stopp'd in the slender shank, by applying the pulpy part of the hand or finger fully and closely to the upper orifice, to hinder the current of the air, and afterwards suffering the oil to run into a different vessel; or if the oil fall to the bottom of itself, it may be permitted to run out first; the course of the other liquor being prevented as before. And here also the oil that adheres to the sides of the glass, may be wash'd and

Processes upon Vegetables.

melted down by hot water. But great care ought to be had in thus separating essential oils; for unless they are made very pure, and entirely freed from their water, spirit, or vinegar, they easily corrupt, and grow mucilaginous, or mouldy.

Cautions and direction relating thereto.

2. When the essential oils of vegetables have thus been thoroughly depurated, 'tis very useful to mix a few drops of pure spirit of wine, rectified without the addition of alkalies, with every ounce of them, in order to preserve and keep them in perfection. Some late writers have observed, that alkalies take off from the fragrance and peculiar flavour of these oils; and, indeed, they seem opposite to the native spirit of vegetables, which resides in their essential oil. But spirit of wine, prepared without the assistance of any fixed alkaline body, will prevent our oils from degenerating, or running into rosin, and defend them from that rancid taste, mouldiness or ropiness, which a little water left among them would, otherwise, soon occasion; after itself is once corrupted.

3. These essential oils, whether light or heavy, ought to be kept in glasses exactly closed; otherwise their subtile part, or distinguishing spirit exhales, whence they become tasteless and inodorous, and scarce knowable from one another. And thus too, by shaking them well with warm water, this will become sapid, odorous and milky, as the oils lose their peculiar taste and smell; and if the operation were frequently repeated with such water, they would at length lose all their force; and those which were different oils at first, appear as one and the same.

Nature of the productions.

4. All oils are thicken'd in their consistence, by age, heat, or repeated distillation; and at length, after some years, by bare rest, come to appear in the form of balsams, or rosins. Thus, having once rectified some oil of turpentine, in high vessels, till it appeared like pure alcohol of wine, in order to preserve therein some very curious anatomical preparations, I found my oil, after some years standing, was grown as thick as turpentine itself; and, like that, had cas'd over the surface of my preparations with a kind of varnish. Yet during the whole time, the containing vessels remain'd close cover'd; so that none of the more fluid parts could escape. Nor can it be objected here, that the oil, like a menstruum, had dissolved some of the glutinous parts of the animal substances it was design'd to preserve; for this was far from being the case. And it will alter its consistence in the very same manner, when suffered to stand alone. If it were not for this disposition of oil of turpentine to grow thick with keeping, whereby it gives a coat to whatever is lodged therein, it would far exceed spirit of wine, in preserving anatomical preparations; because it never siets off the *epidermis*, as the other constantly does.

PROCESS XXXII.

Exhibiting the manner of resolving Balsams into Vinegar, two kinds of OIL, a Rosin, and Colophony; by an example in TURPENTINE.

1. **M**ELT native turpentine, over a gentle fire, till it flows like water, *The process.* and carefully pour it through a hot funnel, into a glass retort made warm to receive it, so that no part thereof may stick in its neck,* and the retort remain but two thirds full; then lute on a receiver, and cautiously begin the distillation in a soft sand-heat, increasing the fire by slow degrees; and there will come over, (1.) A pellucid and gratefully acid spirit, or vinegar, which will mix with water; then the fire being a little raised; (2.) A fine, limpid, subtle, penetrating, and aromatic oil, the lightest of all fluids, except spirit of wine; whence it has obtained the name of aetherial oil. This ascends, mix'd with an acid spirit. (3.) What now remains behind in the retort, is a viscous, transparent, red substance, or rosin, which is inflammable in the fire, soluble in oil, or rectified spirit of wine, but will not mix with water; it also grows hard in the cold, liquifies with a small degree of heat, is very penetrating, and capable, by mixing with the oil and vinegar before separated from it, of being reduced to turpentine again. (4.) With a fire of suppression, there will ascend, whilst the matter crackles in the retort, a very red oil, mix'd with acid spirit; and at last a blackish, thick, fetid, heavy one, which sinks through the other liquors to the bottom of the receiver; having almost the same consistence with the turpentine itself. (5.) There now remains behind a transparent body, call'd colophony, which, when cold, is as brittle as glass; but capable of melting with a small degree of heat. Colophony is no more than rosin, boiled till it becomes very transparent and brittle, so as sometimes to crack spontaneously. It therefore differs from rosin, only in being less viscous, less easy to dissolve, but harder and more brittle, when cold.

2. This process will produce the same effects, and exhibit the same phenomena, in all sorts of balsams; as those of *Mecha, Gilead, &c.* *The cautions it requires.* which all formerly went under the name of turpentine, as we learn from *Theophrastus*. I have perform'd it upon a great variety thereof, and could never find any thing alkaline or inflammable to rise first; but con-

* When the neck of a retort is too long, or its orifice too small to receive the subject, without the use of a funnel, or without loss of time in getting of it in, 'tis usual to take off a part of its neck, and so make a wider orifice, by means of a ring of iron, made glowing-hot in the fire, and directly applied to the

nose of the retort, so as exactly to fit it all round, which will make the glass crack, and break off in the part desired. The same end may likewise be obtain'd, by tying a thread tight about the part of the glass to be cut off, that has first been rubb'd over with sulphur, and then setting fire to it.

Processes upon Vegetables.

stantly a spirit that would make an effervescence with alkalies. The fire must be made very gentle at first, in order to obtain this spirit; for otherwise it will be lost, or never appear distinct. All manner of genuine balsams and turpentine liquify with a small degree of heat; and may be resolved into their several principles by distillation; but 'tis otherwise with wax, which is esteemed a species of balsam. The subject is first melted for the convenience of pouring it into the retort, without touching the sides; for if any part should stick in the neck, it would presently be driven over into the receiver; without any separation of parts. And this is also a reason for heating the receiver; viz. to prevent the turpentine from sticking to its sides; as also to keep it from being crack'd by the hot balsam. Care also must be had not to fill it too high with the subject; for in that case a flatulent matter rising from it, is apt to break the glass in the time of distillation.

How perform-
able to advan-
tage.

3. Recent turpentine may to much greater advantage be distill'd per *vesicam*, with a large quantity of water; by which treatment it will afford the same productions, in the same order. And this is the method commonly practis'd by the druggists, to obtain oil of turpentine in large quantities, with expedition; for the refrigeratory used in distilling by the alembic, greatly quickens the operation. And the boiled turpentine remaining at the bottom of the still, is what they sell for rosin; and which being for a considerable time kept in an open vessel, will at length turn to colophony.

Virtues and
uses of the pro-
ductions.

4. The grateful, acid spirit, or vinegar, which first comes over, is, when purified from the other principles, highly refrigerating, aperitive, diuretic, sudorific, balsamic, or preservative from putrefaction; and one of the best medicines we have in nephritic cases, especially when the stone is lodg'd in the kidneys, or ureters; and for quenching thirst. It appears to be the same production as we first obtain, by distillation, from *lignum vita*; but it retains much less of the empyreuma than that. All kinds of balsamic woods afford an acid spirit, which is the volatile, oily salt of the vegetable; whence it appears very probable, that the acid spirit of guaiacum is of the same nature with the first spirit of this process; being afforded by the balsamic or terebinthinous parts of that wood. Accordingly, if mix'd with water, and injected, glyster-wise, in a *gonorrhœa virulenta*, 'tis an admirable medicine; and of very great service in case of venereal ulcers, spots, and pustules.

5. The fine æthereal oil is an admirable diuretic, healing, relaxing, discutient, anodyne, styptic and balsamic medicine. Its diuretic virtue is so great, that if only a single drop of it be drank along with any other liquor, it will, in the space of a quarter of an hour, give the scent of violets to the urine; and would have the same effect by being barely rubbed upon the abdomen. We have an extraordinary instance of its diuretic virtue, in an accident that befel an apothecary's servant in *Holland*, who, mistaking a bottle of this oil for some other drinkable liquor, took a draught thereof to quench his thirst; upon which he soon after fell into

into a diabetes, attended with a violent *profluvium seminis*, that proved exceeding difficult to stop; and left an ill effect behind it, which the person felt all his life after. Hence, tho' it may, when properly used, be serviceable in the venereal disease, yet being apt to over-relax the vessels, it requires a deal of caution in the management; and those of a tender and delicate constitution may sustain great damage by an unskilful use thereof. 'Tis observable of this oil, that being shook together with the acid spirit which rises at the same time in distillation, they will make for a season a milky mixture, like oil and water; but the oil presently frees itself, and mounts to the top. Whence it appears, that some of those principles which were united in a vegetable cannot be brought into conjunction again, after they have once been separated. And as this oil will not mix with water, it appears not to be of so subtile a nature as pure spirit of wine. This oil has such a power to heat the body, that whoever anoints the extremities of it therewith, may travel unhurt by the frost of the coldest countries. It also restores the limbs of such as have been frozen; and if externally used, by way of prevention in the winter-season, keeps the feet and hands free from kibes, chaps, and chilblains; as it excellently cures them, after they are perfectly form'd. And internally taken in the quantity of a few drops, it has the power, upon account of its warmth, to put by the cold fit of an ague. And in all cases where the tendons are shrunk and contracted, or the limbs are withered, dry'd up, and render'd stiff or immovable by wounds, fractures, &c. this oil has such a relaxing virtue, that being rubbed in upon the part twice a day, with a warm hand, before the fire, it greatly conduces to restore them to their natural state. It is so discutient too, that being rubbed upon cold or hard, scirrhus or cancerous tumors, in the glandular parts of the body, it will resolve them, bring them down, and disperse them. 'Tis likewise a most incomparable anodyne, and, perhaps, the best that is afforded us by chemistry; for when applied hot to any lacerated or mangled nerve, tho' the pain be ever so great, and the symptoms ever so threatening, it soon stops them all, like a charm, and gently constringes, crisps up and warms the injured part, and preserves it from corruption. The styptic virtue of our æthereal oil is so great, that it stops a hæmorrhage like an actual cautery; for which reason 'tis used by chirurgeons in cases of amputation, where the large blood-vessels are cut asunder. For pledgets dipp'd therein, being applied scalding-hot to the mouths of the bleeding arteries, it proves very effectual in closing them, at the same time as it defends them from farther injuries; as inflammations, gangrenes, &c. Lastly, this oil is no less remarkable for its balsamic virtue, than for all the rest. Any vegetable insect, or fœtus suspended in it, may be preserved unaltered, or uncorrupted for a great length of time. Even the human body, if twice or thrice dipt therein, then suffer'd to dry for a few days in the open air, and afterwards dipt, and dry'd again for several times successively, may, by this means,

Processes upon Vegetables.

means be kept, as it were in case of glass, for many ages, without altering its external form, or appearance. This method of embalming was unknown to the *Egyptians*; and far exceeds all those they were possessed of. Yet this is not without its inconveniencies; for the smell of the oil is unpleasant; and, besides, 'tis very apt to be fully'd and obscured by any dust that shall fall upon it: and, in time, it returns to turpentine again; bating for the loss of its acid spirit.

6. The thick red, or blackish, viscous oil, which comes over last, is, upon account of its consistence, less tractable than the former; and not so rich in medicinal virtues: tho' in some degree it abounds therewith. If this be mixed with spirit of nitre, it makes an explosion, and turns to flame.

7. There appears to be no very great difference between the rosin and the colophony of our present process. If the rosin be used internally, it seems to act much after the manner of turpentine; proving diuretic, and presently giving a violet smell to the urine. On account of which penetrating virtue, turpentine is scarce inferior to any other native balsams for medicinal purposes. But colophony is, on some accounts, preferable to rosin; as, particularly, in long preserving the bodies of vegetables, insects, or other animals unaltered; for which purpose it serves almost as well as amber. We are beholden to Mr. Boyle for this discovery; who tells us to melt our colophony gently, and then to dip our subject therein, as it hangs pendulous from a thread, and soon take it out again to cool; whereby it will gain a case, which by repeated immersions may be increased to what thickness we please. So that a beetle, a lizzard, or a frog, for instance, may thus be made to appear as if it were included in a lump of amber. But such preparations ought to be kept in a place free from dust; otherwise the colophony will be cover'd over therewith, and lose of its transparency. Colophony, also, is an incomparable remedy to cause a cicatrix in the nervous, membranous, and bony parts of the body, when they are laid bare. For when well boiled, it may, after 'tis thoroughly cooled, be reduced to a most subtil powder, which being strewed upon such wounded parts, will have a very great effect in healing them up. When applied in this manner, and only covered over with clean, dry lint, itself presently dissolves, prevents the rise of fungous flesh, excellently defends the bone from being corrupted or fouled by the matter, or corroding ichor of the wound, fills it up with solid flesh, and skins it over. Where the small membranous vessels, or nerves of the body are cut or bruised, no better medicine can be employ'd; and I could scarce ever cure contusions on the *tibia* without it: for when the bone is here laid quite bare, plasters are apt to cause much mischief. In all wounds of the periosteum, it has never fail'd me once. It constantly heals without suppurating; and I have performed many extraordinary cures by its means, even in old, stubborn ulcers, where 'tis very difficult to induce a cicatrix, and prevent a relapse.

8. Hence

8. Hence we may learn, (1.) That a volatile acid salt, or spirit is lodged in all the native balsams of vegetables. (2.) That this salt may be so dissolved in the oil of the balsam, as to appear one body therewith. (3.) That balsams change into oil, when deprived of their acid and rosin. (4.) That balsams change into rosin, when deprived of their acid and oil. (5.) After what manner the several degrees of the sun's heat act upon oils, balsams, rosin, and pitch. (6.) And lastly, why those trees which are green in the winter, abound most in balsam. For all ever-greens, as the pine, the fir, the yew, the box, the savin, the juniper-tree, &c. stand in need of a greater quantity of oil, or balsam, to entangle and hold in the vivifying, acid spirit, which is the cause of their perpetual greenness; whilst other vegetables, which wanting this acid, are not so full of balsam, languish and wither in the winter season.

*Collaries
from the pro-
cess.*

PROCESS XXXIII.

Exhibiting the manner of resolving dry BALSAM, collected by animals, into an acid Spirit, and a Butter, or Oil; by an example in WAX; the only known production of that nature.

1. **H**ALF fill a glass retort with fine wax, cut into pieces small enough to enter the mouth thereof, thoroughly dissolve it with a gentle heat, and pour clean, dry, and warm sand upon it, to fill the remaining part of the retort up to its neck; then lute on a receiver, and proceed to distillation, in a sand-furnace, with a gradual fire. There will come over, (1.) an acid spirit, of a very nauseous taste, and a peculiar, fetid, and empyreumatical smell; something like what ascended first in the distillation of turpentine; but more disagreeable to the palate; (2.) upon raising the fire, an oil, or butter that will congeal in the cold; and generally appears white. (3.) And with a fire suppression, the whole remaining quantity of the wax, which appears in the form of a butter.

The process.

2. In the last article, that of rising entirely in distillation, wax differs from all other balsams, which may constantly be resolved into their principles; and always leave some feculent, or terrestrial part behind them. The oil, or butter, is likewise singular in this, that it loses nothing by repeated distillations, but becomes every time more thin and limpid, without depositing any fæces; whereas all other oils constantly grow thick and foul, and leave an earth behind them by cohobation. But the butter of wax, distilled over three or four times running, appears like oil of turpentine, and will not congeal, grow foul, or deposit a sediment.

its nature.

Nature of the
Subject.

3. Wax appears to be no more than an unctuous humor, sweat out at the pores of vegetables, and lodged in small quantities upon the surface of their leaves and flowers; where 'tis afterwards thicken'd by the sun, and scraped off by the rough feet of bees, which are the only animals fitted for that purpose: and these barely collect and scrape it off from plants, for their particular uses, and carry it in their feet to their hives, without receiving it into their bodies, or, perhaps, so much as their gorge. If we examine a piece of rosemary with a microscope in the summer, we shall find its leaves cover'd over with yellow globules, which are the wax, that causes them to feel rough and clammy, or stick to the fingers when touched. Whence we may learn, that many fabulous things have been told us of wax, by some writers upon the *materia medica*; and that in reality it does not belong to the class of animals, but vegetables. Indeed, it seems to be a kind of camphire, like which, upon distillation, it leaves no faces, but proves perfectly volatile; and grows white by being boiled in change of water.

Doctrine of the
Process.

4. Hence we see there are balsams, or oils lodged in vegetables, which may be totally rais'd in distillation, without suffering any separation in their parts, and yet retain their oleaginous nature; which renders the notion of camphire more familiar to us. And, indeed, there may be a great difference between the ways wherein oils are lodged in plants.

Medicinal vir-
tues of the pro-
ductions.

5. The rectified oil of wax is possessed of great medicinal virtues; being of a nature between the expressed oils of seeds, and the æthereal oil of turpentine. 'Tis emollient, laxative and anodyne. When carefully wash'd, and depriv'd of its ill scent, or acid spirit, by shaking it with water, 'tis an excellent remedy; being used externally, in cases where the limbs are dry, stiff and inflexible; or where the juices are thick'd and condensed, so as to form hard tumors; for it wonderfully supple, relaxes and dissolves. In *France* they have found it very effectual in case of costiveness, attended with severe pain; for the relief whereof they only anoint the abdomen with it; which so mollifies and relaxes the fibres, as to procure an easy passage to the excrements downwards. 'Tis likewise an extraordinary remedy for chilblains, chapped nipples, and all cracking and dryness of the skin, whether of the face, lips, hands or feet; provided, as was said before, it be first well wash'd with warm water, which will dissolve and take up its acid part, and clear it from any adhering fordes.

P R O

PROCESS XXXIV.

Exhibiting the manner of preparing, Elæosacchara, or Sugar-balsams; with the productions of the preceding Processes.

1. **T**O eight parts of the finest, dry, loaf-sugar, reduced to powder, add *The process.* one, of any essential oil, and grind them together, in a close marble or glass-mortar, for a considerable time; so as perfectly to incorporate them into one body, or Elæosaccharum; which is to be kept in a dry, clean glass, close stopped, and defended from the air.

2. If the oil be strong, or violently hot, as that of cinnamon, for instance, *How perform-* eight drops of it may be sufficient for an ounce of sugar; for both its *able to advan-* scent and taste are greatly augmented by the operation, if perform'd *age.* in a mortar that is close, to hinder the avolation of its fine, fragrant, aromatic parts. And if this be done, the longer the operation is continued the more perfect the medicine will be.

3. How easy and slight soever this process may appear, its use is very *its excellence* extensive; as teaching us the way of converting oils into salts. *and usefulness.* The ancients, who were unacquainted with sugar, and the method of distillation had, nevertheless, their μέλι-έλαιον, or honey-balsam, instead of our elæosaccharum; but could never prepare it to the advantage that we do; they being obliged to use oils by expression, for those we gain by distillation, which contain the most medicinal part of vegetables. But these being of themselves too fiery to be trusted alone to mix with the juices of the human body; this process shews an admirable way of converting them into a soap of great medicinal virtues, which may be very commodiously administred, and with all desirable advantages. By this means we can, at any time, presently mix any essential oils with water, wine, or what other liquor we please, and so render them potable, without at all impairing, nay, in reality, greatly improving their virtues. And when once such a medicine is prepared, it may long be kept in possession of its full virtues, tho' carried into the remotest regions; being commodiously portable, and at all times fit for immediate service.

4. 'Tis a common opinion, that sugar is prejudicial to the body; but *Nature of the* whoever considers the nature of it, will find it possessed of many excellent me- *Subjects and* dicinal virtues; and that, like all other wholesom things, it proves hurtful *Production.* only when used too freely. It appears to be the essential, or native salt of the sugar-cane, mix'd with a certain proportion of oil, which renders it inflammable. It melts at the fire, dissolves in water, and is sapid; consequently it possesses all the properties of a salt: so that it seems to be an unctuous saline body, or a kind of natural soap. I am there-fore

fore surprized that any physicians should give into the common opinion of its being unwholsom, or filling the body with phlegm, or other ill humors; for it certainly resolves, relaxes, attenuates, and proves serviceable in all distempers proceeding from a viscid cause; and is able to dissolve any glutinous, gummy, or oleaginous substance in the body; so as to render it easy to unite and be carried off along with the more aqueous juices. 'Tis on this account that it conduces to take down the unwieldy bulk of fat, gross habits, or over-fleshy persons; and proves of disservice to such as are too lean and meagre. Thus also, in the tender bodies of infants, it may, when used too freely, bring on the rickets, by over-relaxing the vessels, and dissolving the humors. It is, indeed, prejudicial to the teeth, as being a kind of sharp, penetrating salt; and if applied to the naked nerves, or carious bones, sometimes causes intolerable pain. But, to speak freely, there is no vegetable substance whose nature is harder to determine than that of sugar. It cannot properly be called a salt, because it burns all away in the fire; not an oil, because it readily mixes with water; not a soap, because saponaceous salts can hardly be brought to ferment, as this easily may; after which it affords an inflammable, inebriating spirit, by distillation; but when crude, an acid one, capable of extinguishing fire. It also dissolves in the open air, and runs into a syrup, that by straining becomes transparent; and what is more surprizing, afterwards shoots into crystals. 'Tis not only saponaceous it self, but, as we find, has also the faculty of turning oils to soap. If this were done with fixed alkali, and in the distill'd oils of vegetables, they would lose all their fragrant scent and taste by the mixture; both which are improved by uniting with sugar. It is also easy to separate and recover the essential oil from the sugar, wherewith it was thus mixed, by pouring warm water to the elæosaccharum, and distilling it off by the retort, or alembic. All saponaceous bodies have the faculty of dissolving oils; whence we may learn, that sugar is of a saponaceous nature; for by being ground, and thoroughly united with them, it breaks their parts so fine, that they will now take away, or wash out with water, such spots in garments, as they would before occasion. Thus we see that distilled vegetable oils, when once, by fermentation and distillation, reduced to inflammable spirit, will no longer leave their marks upon cloths.

Use of the process.

5. With elæosacchara, prepared after the manner of the present process, we may make a variety of medicines, suitable to the various intentions of the physician, and endowed with the medicinal virtues of what plant we please. Thus, in order instantly to obtain a rich cordial, to support a person under the greatest depression, or even in the agonies of death, dissolve a little of the elæosaccharum prepared with the essential oils of cinnamon and orange, or citron-peel, in cinnamon-water, and this will directly afford it*.

* This process might furnish the shops with much more effectual medicines than are commonly sold in them; and 'tis pity the hint should have been taken by illiterate tradesmen and empirics, sooner than by regular physicians.

PROCESS XXXV.

Exhibiting the manner of preparing MEDICATED LIQUORS, with the productions of the preceding Processes.

1. **T**O one part of any elæosaccharum add two parts of the medicated salt *The process.* of Tachenius; grind them together in a marble mortar, and, by degrees, pour upon them sixteen times their own quantity of the distill'd water, by fermentation, of the vegetable that afforded the oil for the elæosaccharum; so as to make a perfect solution, or Medicated Liquor.

2. Such a mixture as this will contain, to great perfection, all the active and particular virtues of the plant united together; whence it is exceedingly useful in medicine, and the noblest, or most powerful remedy that can be expected from vegetables, in the most suitable and convenient form. 'Tis made up of the essential oil, the salt and spirit of the subject, which being all the parts possessed of any particular medicinal virtues, are here concentrated, or brought together into one whole. The elder *Helmont* having observed, that chemistry had invented a medicine capable of dissolving all foreign matter in the body, and strengthening the fibres, adds, "But, if we cannot attain to such a secret, it may be sufficient that we make an oily salt; which will have almost the same virtues with the other; and, by uniting the salt of cinnamon with its oil, by a secret circulation, we may obtain an extraordinary medicine." In imitation whereof, I contrived the present process, which will furnish us with such remedies, as I had rather physicians should occasionally make experiment of, than implicitly believe the characters I cou'd deservedly give them. Thus, to make an effectual medicine in case of the colic, from a cold cause, take a dram of the elæosaccharum of fennel, two scruples of the fixed salt of the same; or, because that wou'd come dear, of any other vegetable; for, 'tis the same thing, as we formerly observed; and six ounces of the distill'd water of fennel, by fermentation, mix them together for a liquor to be taken in the quantity of half an ounce every half hour, or oftener, if there be occasion. The elæosaccharum of savin, treated in the same manner, affords an admirable emmenagogue, or medicine to promote the menstrual flux; that of tansy, or wormwood, one to destroy worms in the body; that of cinnamon, another to cure the green-sickness and hysteric diseases; that of turpentine, tho' difficult to mix, an excellent medicine, in case of nephritic complaints, &c. After the same manner an incomparable febrifuge may be prepared for stubborn agues, from the elæosaccharum of wormwood, or carduus; which, in my practice, has perform'd extraordinary cures.

Its usefulness in medicine.

3. The

*Virtues and
uses of the pro-
duction.*

3. The dose of these medicated liquors, and the repetition thereof, must be proportion'd to the demand of the distemper, and the strength of the distilled oil employ'd in their preparation. Thus, a small spoonful of that prepared from the hot aromatic oil of cloves, is a sufficient quantity to be taken at once. In general, they ought to be taken upon an empty stomach; and the dose repeated every hour, or oftener. In case of an intermitting fever, my method is to give the medicated liquor of wormwood, in the quantity of a spoonful, or more; beginning an hour or two before the fit is expected; and repeating the dose once in a quarter of an hour, whilst the patient keeps sweating in a warm bath, and waiting for the paroxysm. This method will cure the most stubborn tertian, unless it be deeply rooted indeed, or proceeds from a scirrhusity, or suppuration in some part of the body. Thus, likewise, in an obstruction of the *menfes*, the medicated liquor of rue, given in proper doses, at due distances of time, for three or four days together, before the accusom'd period, will, with the assistance of a warm bath, used an hour before bed-time, cause them to flow regularly.

PROCESS XXXVI.

Exhibiting the manner of preparing sweet-scented, or apopleptic BALSAMS, with distill'd VEGETABLE OILS.

The process. 1. **T**AKE eight parts of perfectly pure pomatum,* two of clean white wax, and one of any odoriferous essential oil; dissolve the two former together in a glazed, or porcellane vessel, over a very gentle fire, and, after the vessel is removed from thence, add the oil, mix them all well together, and, when the whole is perfectly cold, it will congeal into a balsam, which is immediately to be put up into pure vessels of glass, lead, or silver, and kept close from the air.

*The Cautions
wherewith it
should be per-
form'd.*

2. The essential oil ought not to be added before the mixture of the wax and pomatum begins to cool, lest some of its volatile, or most odoriferous parts should, by the heat, be made to fly off. And, after the three ingredients are thoroughly incorporated together, the containing vessel may be plunged into cold water, to hasten the congelation, prevent any farther evaporation, and to render the balsam the stiffer, and

* The art of making pomatum, in perfection, so that it shall appear extremely pure, stiff, white, and porous, is no inconsiderable secret, and lies in few hands. The unguent, which now commonly goes by this name, is a different thing from that we commonly find described in dispensatories; as being prepared without any apples, or pome-waters. It may, if a person has the secret, be made to great advantage, with little trouble.

Processes upon Vegetables.

III

fitter for keeping. A quantity of *elaeosaccharum*, containing the due, specified proportion of oil, may here be conveniently substituted for the oil itself; but when the oil is very odoriferous, or highly aromatic, its quantity need not exceed that of half, or even a quarter of what is ordered in the process. The proportion of the wax may likewise be diminished, where the balsam is required of a soft consistence, or design'd to be long kept, or in a cold climate: for the wax, renders the balsam durable, in proportion to the quantity employ'd, but at the same time takes off from its odour. The pomatum ought by all means to be fresh, no way discolour'd, but perfectly white, and without any ill scent.

3. These balsams may be made of any colour one pleases, by the addition of a proper pigment: for as they are designed only for external use; How it may be varied. we have no ill consequence to fear from the tinging ingredient, provided it be not a subtil poison: thus a few grains of gum-lac, rubbed fine with one or two of sal-ammoniac, or a little native cinnabar, subtilly ground, and mixed with an ounce thereof, will make them appear of a beautiful red; without changing either their scent or taste. Verdigrease, or the pigment made of the juice of buck-thorn berries, will give them a very fine green; and saffron ground fine, a gold colour: but this will alter their scent; and therefore gamboge ground with a very little sal-ammoniac, to take away its clamminess, or the powder of turmeric-root, may be used in its stead. And by this means we may suit the colour to that of the oil of the plant made choice of for our balsams. The general method of tinging them, is this. When the wax and pomatum have been melted together, removed from the fire, and begin to grow cold, cast in your pigment, well prepared, or ground fine in a mortar, and mixed with a little pomatum; then keep the mixture stirring, to incorporate all thoroughly together; and soon after add the aromatic oil, and blend the whole into one uniform and consistent mass; keeping it in motion till it grows perfectly cold.

4. As these balsams are designed only for perfumes, to refresh the spirits, and add vigor to the nerves; those oils ought to be employed in their preparation, which may most conduce to that end. Such are the essential oils of cinnamon, orange-peel, cloves, lavender, nutmegs, mace, *Indian cedar*, rhodium, marjoram, baulm, organum, roses, j. smin, and the *Philadelphus Athenai*, the scent whereof is exceeding grateful, and beyond that of j. smin-flowers. The expressed oils best fitted for this process, are those of mace, and nutmegs, the opobalsamum of *Arabia*, for we have none that comes from *Syria*, and the white *Peruvian* balsam, which has a very delightful fragrance. How perform-able to the best advantage.

5. The *Italians*, who are thought to prepare these balsams in great perfection, and do it principally for the use of the duke of *Florence*, who makes rich presents thereof to foreign ambassadors, chuse some essential oil, as that of nutmegs, for the basis of their compositions. But this they shake, and wash so long in water, that it loses all its peculiar-

liar odour; which is so far from being of any advantage to the balsam, that it doubtless proves a disservice thereto. For, as we formerly observed, whenever an oil has lost its specific scent, it cannot be distinguished from any other common, unctuous, or fat substance.

Origin of the name.

6. The word balsam is of Hebrew, Chaldee, or Arabic extract; and from thence transmitted to the Greeks and Romans, as we learn from *Florus*, who tells us, that "the Roman army met with balsams, in their passage through the odoriferous groves of Asia." Balsam, in Hebrew, is called *בשם*, *Baal Shemin*, the prince of oils. All balsams took their names originally from that of the valley of *Hieruchuntum* in Syria, where it is found to this day, and called *Opebalsamum*. This is mentioned by *Theophrastus*, *Josephus*, and others. The genuine balsam, or *Opebalsamum* itself, is so exceeding precious, that the whole stock of it is appropriated to the service of the grand *Seignior*; that person being adjudged guilty of a capital crime, who shall transport any part thereof to foreign countries. Our merchants bring away the balsam of *Mecha*, instead of the *Opebalsamum*; only mixing it with a proper proportion of the balsam *Copaiba*, to give it a flavour.

Medicinal uses of the production.

7. These balsams may be of use in hysteric cases, in the palsy, apoplexy, and lethargy, arising from a cold cause; for, when smelt to, they are found wonderfully grateful and refreshing. That prepared with the distilled oil of rue, is most proper for hysterical disorders; that of lavender, for apoplectic, and other cephalic cases, &c.

* These are the balsams, or perfumes, which people commonly carry in their pockets, included in little silver, or ivory boxes, or the heads of their canes, to smell to occasionally; and may be suited to every constitution, so as to prove grateful and agreeable, even to those who have an aversion to the luscious sweets of musk, civit, and ambergrease.

INTRO-

INTRODUCTION

TO THE

HISTORY

OF

FERMENTATION.

PROCESS XXXVII.

To shew that all kinds of crude MEAL and MALT, steeped in water, will not, without a previous FERMENTATION, afford a spirituous, or vinous liquor, by distillation; but only one that is almost scentless and insipid.

1.  IX any kind of meal, or ground malt, with warm water enough to make it of the consistence of panada, and distil the mixture by the alembic, with a gentle heat: what comes over will be only an insipid, unflammable water, with very little scent, and capable of extinguishing fire. *The process.*

2. The vapor raised in the operation condenses into drops, like dew, in the head of the still, and does not presently run down in veins to the worm. The water which thus comes over, is not perfectly pure and scentless; because all vegetables contain something of a subtle, tho' unflammable, native spirit; as we learn from our first process; and some part hereof is retained in the meal or malt: but if the liquor be drank, it has all the effects of water; and not any one of wine. *Its nature.*

3. Hence it appears, that what is called the first fermentation, or the reduction of any grain into malt, will not fit it to afford an inflammable spirit. *The doctrine is afforded.*

Processes upon Vegetables.

rit by distillation; another fermentation with liquids, being absolutely requisite for that purpose. And this holds equally true of all kinds of pulse and grain.

PROCESS XXXVIII.

To shew that Honey made into hydromel with water, affords no spirituous liquor, whilst it remains CRUDE, or UN-FERMENTED.

The process. 1. **D**ILUTE Native Honey with five or six times its own quantity of water, let it stand to settle, afterwards run it through a flannel strainer, and directly commit it to distillation; by which means, if two thirds of the whole quantity be drawn off, it will only yield an indolent water, retaining something of the smell of Honey, or the flowers from whence it was collected, but nothing of a spirituous, or vinous nature; for it will neither inebriate, burn in the fire, nor run in veins, but form into drops, on the still-head.

Virtues of the subject.

2. The subject of this process is the *mulsum* of the ancients, so frequently met with in their writings; and famous for its laxative, aperitive, and refrigerating virtues; and, indeed, it sometimes proves a successful remedy, when stronger and more elegant medicines have failed.

Virtues of the production.

3. The distill'd water of this hydromel, or *mulsum*, is recommended against obstructions and inflammations in the fine, capillary, or most delicate and tender vessels, and, particularly, in suffusions and inflammations of the eyes; being externally applied thereto, after it has been warm'd over the fire. And, indeed, for this purpose, 'tis a very effectual, tho' a mild and gentle remedy. On which account it has been held as a very great secret in France.

The doctrine of the process.

4. This process informs us, that even the most pure, perfect and best elaborated of vegetable juices, will not by distillation afford a vinous spirit. Honey is a subtile juice, brought to the greatest degree of perfection by the heat of the sun, and all the requisite stages of circulation; whence it at length comes to be lodged in proper cells, which are always found in the flower of the plant; whereof it therefore is the ultimate and most consummate production. It appears to be the very marrow of the flower, from whence it distils in transparent drops; as is plainly seen in the lily, the *Corona imperialis*, the aloes-plant, and other vegetables, whose flowers are of the larger kind. Hence many are of opinion, that it is the nutriment of the embryo in vegetables, which the bees suck out of their flowers, and lodge within their gorge; where being detain'd a while, and possibly farther concocted, it becomes of a thicker consistence. Yet we see even this perfect vegetable juice contains no inflammable, or vinous spirit, before it has felt the force of fermentation. And the same holds universally true of the juices of all manner of fruits, and even of grapes themselves, tho' ever so pulpy, ripe, and perfect.

CHEM

CHEMICAL and PHYSICAL HISTORY OF FERMENTATION, VINOUS and ACETOUS.

1.



FERMENTATION is a change produced in vegetable bodies, by means of an intestine motion excited therein; the effect whereof is this, that the part which first rises from them in distillation, is either a thin, fat, acrid, hot, transparent, volatile, and inflammable fluid, that will mix with water; or else a thin, acid, pellucid, less volatile, uninflam-^{able} liquor, capable of extinguishing fire. *Fermentation, what.*

Authors have been at a deal of pains to deliver an adequate definition of fermentation; but with all their care, they differ widely from each other; and not one of them affords us an accurate and genuine description of the thing. And, for my own part, I freely acknowledge, that the definition here laid down rather describes the effect of fermentation, than declares

declares what it really is: but I could not define it otherwise, without running into considerable errors. In matters of natural philosophy, 'tis not a rational definition that will inform us of their nature; but whatever is of that kind can only be clear'd up, and made intelligible by observation; that is, by the knowledge which arises from an accurate consideration of things.

Numerous phenomena present themselves in the business of fermentation; and whoever would faithfully describe, or rightly define that operation, ought duly to weigh and consider them all. The authors who have wrote upon fermentation attempt to give us the definition of it from those phenomena which themselves observed therein; but, not being careful to remark, and consider them all, and distinguish between them, they assumed some particulars as essential and peculiar to it, which are common to other things as well as to that: and by this means, they were led into error. He who would give an exact description of fermentation, must set down what is constantly to be observed in it, and not to be found in any thing else; otherwise that will be taken for an effect of fermentation, which properly never belong'd to, or was produced by it. Fermentation, in itself, is a thing utterly unknown to us; and we can only become acquainted with it from its effects; we, therefore, include in our definition the ultimate difference it produces; by which it is distinguish'd from every other operation in nature. We say then, that fermentation is a change produced in vegetable bodies, because the effects of a true and genuine fermentation were never observed to be produced in animal or fossil substances; and an intestine motion is said to be its effective cause upon this score, that fermentation is not, like some chemical operations, perform'd by triture or attrition. The liquor obtained by means of it is called thin, because none appears to be thinner than the spirit of fermented vegetables; acrid, because it acts almost like fire, when applied to the tongue, or other parts of the body; volatile, because there appears to be no liquor that is raised with greater ease: but 'tis this liquor's being totally inflammable, and at the same time capable of mixing with water, that ultimately distinguishes fermentation from all other operations in nature: for neither putrefaction, digestion, effervescence, nor any thing of that kind, will ever afford a liquor at once possess'd of both those qualities. Putrefaction indeed, as well as fermentation, is perform'd by means of an intestine motion; but the former will never produce either of the liquors above described as the effects of fermentation; that is, neither a vinous, nor an acetous liquor. We see then, that there are two different effects of fermentation, the production of an inflammable spirit, and an uninflamable acid; and whatever operation will afford neither of these liquors, is improperly called fermentation: which, therefore, can only take place in the vegetable kingdom; for all the art in the world, so far as hitherto appears, will never gain such spirits from animals or fossils; and consequently, never excite an actual and real fermentation in them:

them: for fermentation is the single operation in nature, by which such spirits can be obtain'd.

2. Any vegetable liquor so fermented as to afford the inflammable spirit above-mention'd for the first thing in distillation, we call wine: but if the liquor be so fermented as first to afford the acid, unflammable one, 'tis term'd vinegar; by which we mean every thin, acid, volatile, vegetable liquor, capable of extinguishing fire. So likewise, under the name of wine, we include beer or ale, mead or metheglin, cyder, perry, all sorts of artificial wines, and whatever liquors afford spirits possess'd of the properties before set down. The like is to be understood of vinegar, which is obtainable from all the same bodies that afford wine: so that we have either the wine, or vinegar, of all sorts of fruits, as of grapes, currants, mulberries, cherries, &c. all sorts of grain, as barley, wheat, oats, &c. all sorts of pulse, as beans, pease, tares, &c. all sorts of roots, as turneps, carrots, radishes, &c. and in short, of all sorts of vegetable substances, even grass itself.

Wine and vinegar, what and whence.

3. All the bodies capable of being changed by fermentation, either into wine or vinegar, are said to be fermentable bodies; and because such a change can only be wrought, so far as we know at present, upon vegetables, these alone are accounted fermentable: tho' at the same time we do not say, that every vegetable substance is naturally capable of fermentation. Mustard-seed, onions, &c. afford a fetid liquor by distillation; which is rather the effect of putrefaction than fermentation in them.

Fermentable bodies what.

4. Any matter, which being mixed with a fermentable body, increases its intestine motion, or excites, or forwards the fermentation, is call'd a ferment. And, according to the doctrine before deliver'd, nothing can properly be called so but what will produce either wine or vinegar.

Ferments what.

5. The subjects of fermentation, or fermentable bodies, being separately consider'd, are very various, and almost innumerable: we shall therefore, consider them in the several classes under which they are ranged by the different ways made use of to ferment them. In order to produce wine from grapes, a different method must be taken from that which we make use of to obtain it from barley. For, if grapes were first steep'd in water, then drain'd of their moisture, and afterwards thrown into heaps, or couches, as barley is, in order to be made into malt, they would rot, and afford nothing at all of a vinous nature. Hence there appears a necessity for considering vegetable, or fermentable bodies, according to the manner which ought to be pursued in their respective fermentations. And since several of them may commodiously be treated in the very same manner, 'twill be convenient to reduce as many as are capable of it to the same class; whence, by going over a few such classes, we shall readily understand how to ferment all sorts of fermentable bodies;

Several ways of fermenting vegetables, according to their classes; viz.

Processes upon Vegetables.

bodies; without being at the pains separately to consider every particular subject of the vegetable kingdom.

The mealy seeds. 6. The first class, according to this method, will consist of the mealy seeds; by which we mean all the grain, that, being fully ripe, and well dry'd, may be reduced, by grinding, to a light meal, or flower, that is neither clammy, nor unctuous. Of these seeds there are three kinds; *viz.* (1.) All manner of bread-corn, growing in ears, and having a grassy leaf; such as the several sorts of rye, barley, wheat, rice, millet, buck-wheat, and other seeds, which, on account of their likeness, are reckon'd among them; such as flax-seed, canary-feed, spelt, oats, the seeds of melons, pumpions, cucumbers, &c. (2.) The several kinds of pulse; as beans, peas, tares, lentils, cicers, or the chich-pea, french-beans, hearth-peas, lupins, cammoc-feed; with the mealy seeds of all other podded vegetables, which bear a papilionaceous flower. (3.) All the nuts, which are not over-stock'd with oil; such as the chest-nut, the hazel-nut, the wall-nut, the pistachio, the almond, the cocoa-nut, &c. with their subordinate species. The more unctuous kinds of nuts may likewise be ranged under this class, provided they are first dry'd, or otherwise freed from their too great proportion of oil, before you commit them to fermentation.

Summer-fruits. 7. Under the second class we range all the pulpy summer-fruits, which, when ripe, affect the tongue with the sense of acidity and sharpness; as pears, apples, medlars, services, apricots, peaches, plumbs, &c. various kinds of berries, as the goose-berry, the mulberry, the elder-berry, &c. cherries, grapes, currants, &c. melons, pumpions, &c. Under this class also may be ranged all manner of bulbous, pulpy roots, growing in the ground; if they are but first depriv'd of their volatile, alkaline salt, which is apt to determine them to putrefaction; such are turneps, parsnips, carrots, onions, garlic, &c. for, notwithstanding their alkaline nature, these will afford a vinous spirit, after they have begun to sprout. To these we may also add lemons, oranges, citrons, &c.

Juicy parts of plants. 8. The third class takes in all the juicy parts of plants, as the leaves, flowers, stalks, and roots; provided they are not too oily, or too alkaline; in which case vegetables will rather putrefy than ferment; and accordingly, some antiscorbutic plants, as scurvy-grass, brook-lime, mustard, &c. being fermented, and committed to distillation, yield a spirit, which proves rather alkaline, than acid or inflammable.

Express'd vegetable juices. 9. The fourth class contains the fresh expressed and native juices of all kinds of vegetables, especially of the subjects specified in the second and third class; to which may be added, all the native saline liquors, that distil from wounded plants; as the tears of the vine, the wall-nut, the beech-tree, &c. which presently fall to fermenting, if let stand in a warm place. By the way, *Helmont* tells us, in his treatise *de Lithiassi*, that he observed a birch-tree to weep a very large quantity of liquor about the end of the month *February*, and the beginning of *March*; which being

being drank, prov'd of great service in case of the stone: and Mr. Boyle, coming to make the experiment, found, that if the liquor was used fresh, as it came from the tree, it had a very good effect in that distemper; but none at all after it was once grown stale: accordingly, *Helmont* himself cautions us, not to let this juice ferment before 'tis given for the purpose already mention'd, "left (says he) from a cooling liquor, as it is, it should become heating."

10. Under the fifth class come the most perfect of all vegetable juices, viz. *Unctuous and perfect juices of vegetables*, those which are unctuous, condensed, and elaborated by nature herself; such as honey, manna, sugar, the pulp of *casta fistularis*, or the pudding-pipe-tree, with all other kinds of concreted juices capable of dissolving in water; or such as are neither balsams, gums, nor resins. All these juices are, doubtless, to be esteem'd as vegetable productions: 'tis impossible we should question, whether honey is of a vegetable nature, or not, when we know it to be a thing which the bees gather from flowers, and which they neither take into their mouths, nor lay up in their stomachs, but commit to a particular cavity, or receptacle made on purpose to receive it; from whence they can again discharge it unalter'd. Thus also, we are well assured, that manna is not a vapor, or dew, let down from the upper regions; but a humor, that being made to sweat from the leaves of trees by the sun's heat, is gather'd early in the morning, whilst it lies condensed upon them. In like manner, sugar, and other similar juices, are to be esteem'd as vegetable bodies.

11. The sixth and last class of fermentable bodies consists of the *and river-waters*, waters of those rivers, in which large quantities of vegetables have been thrown, and dissolved; as must be the case more particularly in the rivers upon which stand very large and populous cities; as the *Thames*, the *Seine*, &c. For, if these waters are taken up in warm weather or climates, and committed to proper vessels or casks, they will at length ferment. *Wand-woords* tells us, in his treatise of fermentation, that this was observed of some water taken up under the equinoctial line; which might proceed from the ferment, left in the containing casks by the vegetable liquors they held before. Some *English* men bound upon a voyage to the *East-Indies*, having fill'd several hogheads with *Thames*-water to take along with them, observed an intestine motion in it when they came to the *Equator*; and found it afterwards turn'd into a kind of vinous liquor, capable of affording an inflammable spirit by distillation. But this, without dispute, proceeded from the flowers, leaves, roots, or other parts of vegetables, which continually fall, or are wash'd down into that river. But these particular waters are found in a state of putrefaction, before they put on a vinous nature; and their fermentation is observed to be promoted by any fermentable body thrown into them; or by being only kept in casks, which before contain'd any fermenting liquor: so that water appears not, properly and strictly, to ferment of itself, but by accident.

Processes upon Vegetables.

accident only. This seems to be farther confirm'd by some repeated experiments made in *England*; whence it appears, that those waters which have for long time run over vast tracts of land, are the most disposed to ferment in the casks; since so long a course must needs give the greater opportunity for them to be mix'd and impregnated with vegetables and their juices.

*The requisites
to fermentation.*

12. In order to fit any of the fermentable bodies before-mention'd for fermentation, there are several particulars requisite; as (1.) maturity. The juice of unripe berries, as of currants, or goose-berries, for instance, will scarce be brought to ferment at all; whilst it is very difficult to hinder their juice, when fully ripe, from falling spontaneously into fermentation. Thus, the juice of unripe grapes, being incapable of fermenting, is a rough, acid liquor, call'd verjuice, that will for several years remain in the same unactive state; but, after they are come to maturity, it can no sooner be pressed into the vessel, than it becomes a fermentable, spirituous fluid. (2.) Another requisite to prepare a body for fermentation is, that it should contain only a moderate proportion of oil; for, if it either exceeds in the quantity, or be entirely destitute of oil, it will never be brought to ferment at all. Thus, almonds, fennel-seeds, &c. are always deprived of their oil before we attempt to ferment them: and unless this were done, they would also be apt to grow rancid. (3.) The bodies intended for fermentation must not be too acid or austere; as is plain from the acid juices of unripe fruits, which are greatly indisposed to ferment: and so likewise the rough, austere juice of tormentil, for instance, is with great difficulty managed by fermentation. (4.) The last thing required to fit and prepare a body to undergo fermentation, is the property of dissolving in water; for want of which, all acid bodies, and such woods, roots, and herbs as are hard or dry, become unfit for this operation; for, unless the parts of these bodies are dissolv'd, the requisite intestine motion thereof will not ensue; but, without such motion, fermentation cannot subsist. Hence honey itself can never be made to ferment, whilst it retains its natural thick consistence; but being dissolv'd by heat, or let down with water, it immediately enters the state of fermentation. On the other hand, so violently as the juice of grapes affects this state; yet, if immediately after it is expressed, it be reduced, by boiling, to the consistence of a jelly, 'twill lie quiet, and never ferment at all, unless it be again diluted, or let down with water.

13. According to the definition above laid down, a ferment is any matter, which, being mix'd with a fermentable body, expedites the fermentation. And, of such ferments there are two kinds, the natural, or spontaneous; and those produced by fermentation. Some indeed pretend, there can be no fermentation without a ferment; but then we should be at a loss to account for the first ferment that was ever employ'd.

Processes upon Vegetables.

121

ploy'd. On the contrary, it is very manifest, that fermentation may be spontaneous; for, we see, that the recent juices of some ripe plants cannot be pour'd out of one vessel into another, but they fall of themselves into a state of fermentation. The spontaneous or natural ferments then are (1.) All the fresh expressed juices of fully ripen'd plants, which easily run into fermentation. And (2.) honey, manna, sugar, *casta fistularis*, and the like thick, or inspissated vegetable juices, which cause a strong fermentation. (3.) The ferments produced by fermentation, are the fresh flowers, or yeast, of any fermenting vegetable juice, or liquor, as of wine, beer, &c. By flowers, or yeast, we understand that light frothy matter, which covers the surface of the fermenting liquor in the nature of a tender crust, and which, being added to any other fermentable juices, will excite a fermentation in them. (4.) The fresh *faces*, or lees of any fermenting liquor, as of wine, ale, beer, &c. For, all fermentation divides the liquor, which is the subject of it, into three parts; viz. the flowers, or yeast, which possesses the uppermost place; the operating, or fermenting fluid, which lies in the middle; and the gross, and seemingly exhausted matter, which, falling to the bottom of the vessel, is known by the name of lees, sediment, *feculence*, or mother, that will, if raised again into the liquor out of which it was precipitated, cause it to work afresh. Thus, when a hogshead of wine has done fermenting, and is fined down, if the vessel be any way shook, or disturbed, it will grow turbid again, and ferment anew; as vintners very well know. For, such as were the flowers in the act of fermentation, such is the mother after the action is over. (5.) Acid paste, or baker's leaven, which is no more than any kind of meal brought into a close lump, by means of water, after the same manner as common bread is made; for, this being set in a warm place, during the space of four or five days, it will first swell, then turn very acid, and at length become a ferment. Whence we are furnish'd with an artificial way of preparing a ferment, upon occasion, when a natural one cannot be procured. And it is a custom with bakers to lay by a lump of their dough, to serve, as leaven, for the next bread they make. (6.) Those ferments, which reside in, or stick to the sides of the casks that have contained fermenting liquors. For, such casks will, of themselves, raise a fermentation in the liquors committed to them; and *Helmont* was of opinion, they might be capable of doing this for ever. Upon account of this inherent ferment it is, that old-season'd vessels*, or such

* 'Tis very remarkable, tho' a thing well known to brewers and vintners, that a new cask checks the fermentation of vinous liquors, and renders them weak and spiritless: for which reason, they never chuse to make use of such a cask before it is season'd, as they call it, by having first contain'd some spiritu-

ous, or fermented liquor, or other, which, being plentifully drank in by the wood, the original liquor comes to be deprived of a large proportion of its spirit, and more fermentable part; whence the remainder must needs taste flat and vapid.

*Heterogeneous
ferments.*

as have long been employ'd by vintners, or brewers, bear so great a price among them. This is certain, that even must itself will not easily ferment in a new and pure vessel; but with the greatest facility, if put into one that has before contain'd fermenting juices: for the parts of the fermenting liquors with which such a vessel must have been impregnated, presently rouse and determine it to action. (7.) Besides the ferments already mention'd, there are some which appear to be heterogeneous, or ferments, improperly so called; as the white of an egg beat into a froth, which is used when the liquor to be fermented proves too dilute or thin to sustain the operation: for, in this case, the fermentable parts of the fluid easily extricate themselves, and so fly off, for want of something to detain and keep them in the body of the liquor; which, therefore, requires some viscid substance to be mix'd with it, in order to prevent this avolation of its subtile parts: and this cannot be more commodiously effected than by the white of eggs. Thus, were we to ferment the juice of roses, for instance, 'twou'd be requisite, first, to mix the white of an egg with it, because it is by much too thin and watery to ferment of itself. (8.) Of the like heterogeneous kind of ferments are all fixed and acid salts. Thus, if the liquor design'd for fermentation be too acid to work kindly; the addition of an alkaline salt, as that of vine-branches, or any saponaceous substance, will, by taking off from the acidity, fit it for, and so promote the operation; but, if the liquor be of itself too alkaline, then tartar, or the like, ought to be added to it, to promote the fermentation. But this does not happen because either the acid, or alkaline salt is an actual ferment, as some chemists have vehemently contended for the alkaline; but, because the salts employ'd respectively temper, and take down the predominant acid or alkali, which before hinder'd the fermentation of the liquor. And, if such salts should, in due quantities, be mix'd with any proper subject of fermentation, possessed of all the qualities above set down, as requisite to it, the operation would be entirely check'd and prevented; so that alkaline bodies may as well be said to hinder, as to promote fermentation. (9.) And lastly, of the same sort are certain austere, or rough-tasted substances; as all harsh and green fruit, pomegranate-bark, and flowers, the tamarisk-bark, crab-apples, unripe medlars, &c. which, when the liquor design'd for fermentation, is too much broken in its parts, or dissolv'd in its texture, bind it together again, by their astringent quality; so that, tho' it was before too thin and aqueous, it is now reduced to a proper consistence for fermentation. Thus, when must proves thin and watery, it will not ferment kindly, unless some austere, or astringent ingredient, as red rose-leaves, or the like, be added to it, to thicken and improve its consistence; and, at the same time, prevent the air it contains from making too easy an escape. But, when a liquor is too austere, or its roughness proves so great that it cannot ferment, the addition

of a fixed alkali, in a proper quantity, will remove the obstruction, and leave it at liberty to work. So likewise, when the operation is prevented by too large a proportion of acid in the liquor, the method is to throw chalk, crabs eyes, bole-armeniack, or the like, into it; but, if it be too unctuous, or oily, as is the case in some *Spanish* wines, salt of tartar is made choice of: and thus, as circumstances alter, different bodies are employ'd to stop, or promote fermentation in liquors.

And this is all we have to say on the subject of ferments. As for those who pretend there are particular ones residing in the human body, it lies upon them to shew, that they really exist, and have the properties belonging to actual ferments; which, it is my opinion, they will not easily do.

P R O C E S S XXXIX.

Exhibiting the manner of preparing the first class of FERMENTABLE BODIES, viz. Bread-Corn, Pulse and Nuts, for FERMENTATION.

1. **T**HE subjects of the first of those classes into which we distributed all fermentable bodies, viz. eared-corn, pulse and nuts, are prepared for fermentation in the following manner. (1.) They are put to steep, during the spring-season of the year, in warm rain-water, till they appear to be thoroughly drench'd and soak'd, or render'd soft and tumid; which will usually require the space of twenty-four hours, but more or less, according as the season proves cold or hot. (2.) The water being well drain'd off from them, they are, in some moderately warm place, thrown into beds or couches about a foot high; and in this state they must be left till they begin to conceive a heat, and to shoot or sprout; by which means their oil is broke fine, and render'd volatile. (3.) But their farther growth ought now to be immediately prevented, by throwing the whole couch abroad, thinning its ranks, and exposing it to the air, the wind, the sun, or fire, that it may be thoroughly dried. (4.) Lastly, the seed so prepared is to be broken, and reduced to a kind of coarse flower or meal, called by the name of ground-malt; which fits it to yield its virtues readily to water. And now tis ready to be brew'd into a spirituous liquor, which we scruple not to call by the name of wine. *The process.*

2. Rain-water is here made choice of to macerate the grain, because it abounds more in active principles than water of any other kind, especially in the spring of the year; accordingly, river-water is not found *Directions relating to it.*

found so good to brew withal, nor the winter a time so convenient for it: the best malt-drink is always observ'd to be that which was made with rain-water, and in the spring-season; for, such water, at this season, is enriched with the unctuous, and active exhalations of vegetables, which, during the preceding winter, were shut up, and not suffer'd to go off, and diffuse themselves into the atmosphere. If the heaps or couches, into which the macerated grain is thrown, be made too large, or deep, the middle of them will be scorcht and burnt up, before the outsides are warm; and, if they are made too small, the subject will not sprout kindly. For, in this case, the vegetable seeds being thoroughly saturated, and plump'd up with the water wherein they were set to steep; and afterwards, by means of a strainer, sieve, or otherwise, freed from all the superfluous moisture, and then thrown into heaps; the little bodies here keep each other warm by their mutual pressure and contact, till at length they grow so hot, that the hand cannot, without pain, be thrust into the couch. And now it is that they begin to sprout, and shoot; but, as soon as ever the leaves appear to have left the roots 'tis time to put a stop to their growth. 'Tis the nature of all entire and perfect vegetable seeds, if they have once imbibed any moisture, and are either thrown into couches, or lie otherwise cover'd, to grow warm and sprout; that is, the *embryo* in them is moved, begins to expand itself, and shoot out its roots; and, if they remain in this state for the space of twelve hours, and be afterwards distill'd, they will afford a fetid, urinous spirit: and even the coldest plant that grows will do this. It is manifest from the process, that the steeping the grain or seeds in water opens their bodies, and renders them soft and yielding; as also, that heat puts their parts into motion: which shews us the nature of vegetation, or the manner in which all vegetables grow. The farther growth of the grain in the couch should be prevented, at the instant of vegetation, otherwise all the spirit of the vegetable seeds would be lost, and the mealy part that was left behind be render'd incapable of dissolving in water. The brewers in *Holland* have a particular engine for this purpose, by means of which they can suddenly stifle the vegetation, and stop all farther growth: but, oily seeds may be allow'd to germinate something longer than others, tho' none of them should be suffer'd to sprout much: to prevent which, they ought instantly to be dry'd; for, when once they are thoroughly deprived of their moisture, they will cease to grow. And he is esteem'd the best artist in this way, who can render his grain soft and sweet, without suffering it to shoot long; which wou'd consume the oily part of the seed, whereby its mealy and spirituous quality would be de-

deftroy'd. 'Tis therefore, to be speedily dry'd: * but, if fire be made use of for this purpose, it fhould be gentle, or elfe it wou'd fcorch, or burn the grain; in which cafe, the fpirituos liquor prepar'd from it wou'd be of a higher colour indeed; but it wou'd have an empyreumatical tafte; that is, it wou'd retain a ftrong tafte of the fire, or the fcorch of the feed. To avoid this inconvenience, 'tis the cuftom in *Holland*, to dry the feed they treat after this manner in the wind; which, tho' it performs that office more flowly than the fire, feems the more natural way. Barley prepared after the manner above defcribed, is called malt; or, in the language of *Tacitus*, *de moribus Germanorum*, *frumentum corruptum*; but there is a great difference between corn and malt; and even between crude barley and the malt that is made of it. For, firft, plain barley is not fweet, but retains the natural tafte of its plant, and feels rough and clammy in the mouth; whereas, malt has a faccharine fweetnefs, bites crifp, and breaks between the teeth into a foft and folvable meal. Again, crude barley diffolves with difficulty in hot water, and at beft, makes but a vifcid and glutinous folution with it; whilft malt is fo difpofed to unite with water, that it diffolves, as it were, fpontaneoufly therein; and, if the water be heated, communicates all its virtue, and its whole fubftance to it, excepting only a chaffy husk, or *caput mortuum*: nor can it be brought to form into a pafte with water, as all corn, and in particular barley, readily does. Laftly, malt being apt to run into a violent fermentation in the fummer-feafon, 'tis a rule, not to brew with it alone, at that time, but to mix it with ground-barley, which never underwent the procefs above defcribed; in order to abate of its violent difpofition; otherwife the vinous fpirit wou'd fly off, and be loft in the fermentation: but, in the winter, it may fafely be committed to that operation without any fuch mixture. This procefs is accommodated to all the vegetables ranged in our firft clafs; viz. eared-corn, pulfe, and nuts: fo that, if any one defires to make a wine of chefnuts, walnuts, acorns, or the like, he need only thus fteep them in water, till they juft begin to fhoot; then fpeedily flop their farther growth, by drying them gently before the fire; and laftly, grind them: for, being now committed to fermentation, a very grateful and pleafant wine will, by this means, be obtain'd.

* Our malfters do not immediately remove their macerated and fprouting grain from the wet-couch, as they call it, to the kiln, but gradually prepare it for the action of the fire, by throwing it abroad in shallow beds, and frequently turning, or fpredding it thin over

the whole furface of a large floor; where the air, having free accefs to it, carries off its moi- fture, and leaves it in a fit ftate to be readily dry'd, or crifp'd up by the gradually increafed fire of the kiln.

PROCESS XL.

Exhibiting the manner of preparing, or Brewing Vinous LIQUORS from corn, pulse, and nuts; by an example in MALT.

The process. 1. **F**ROM the vegetable seeds of the first class, prepared after the manner described in the last process, there are two ways of obtaining wine, by means of fermentation; but never without it; viz. either by fermenting the meal of crude corn, or ground-malt, for instance, together with its husk, chaff or bran, according to the method formerly deliver'd, in the process for drawing the waters of fermented plants; or else, after the following manner, which exhibits the art of brewing. (1.) Upon any quantity of ground-malt pour as much warm water as will bring it into a kind of thin pap, or panada; and let them stand together for the space of twelve or sixteen hours. (2.) When the infusion is perfectly made, or the water fully saturated and impregnated with the flower of the malt; all the liquor must be suffer'd to run off from the grains or husks. (3.) The liquor thus drawn off is afterwards to be boiled up to a due consistence; which the higher that is, the stronger, or more vinous will be the liquor after fermentation; and the fitter for keeping. (4.) The liquor thus boiled must, after it has been suffer'd to cool again, be put up, to ferment along with a due proportion of ale-yeast into casks, the apertures or bung-holes whereof are but lightly cover'd. (5.) And after the fermentation ceases, the liquor is to be kept close stopp'd up in the same vessel.

Directions with regard thereto.

2. The water here first poured upon the malt, ought not to be scalding-hot; much less shou'd it be in a state of boiling; for, then it wou'd scald the malt, or run into it hard crusty, clods or lumps, as if it were burnt, and so prevent it from giving out its virtue. But, if the water be only moderately hot, it will imbibe, and dissolve all the mealy part of the malt, and leave nothing but the dry and chaffy husks behind. After the liquor is fully fermented, and stopp'd down, we call it beer, ale, or not improperly, barley-wine; for, it will afford an inflammable spirit by distillation, having no manner of empyreuma, or tang of the fire, and not possibly to be distinguished from the genuine spirit of wine. *Tacitus*, therefore, did not speak improperly, when he said of the *Germans*, that they made a wine of malt, or prepared corn. This kind of liquor, we find, was not unknown to the ancients. *Herodotus* in *Euterpe* speaks of it under the name of οἶνον ἰν κριθῶν, or barley-wine. And *Diodorus Siculus* tells us, that the *Greeks* made a certain liquor, call'd ζῆθος, that is, barley-drink or beer, which was in no respect inferior to wine.

3. In

3. In order to fit the subjects of our second class for this process, *How all other subjects are so be fitted for this process; as those of the second class.* viz. pulpy summer-fruits, and the roots of bulbous plants, in case they prove crude or hard, they are to be first boiled in water, and afterwards bruised; which will dispose them for fermentation: but, if such subjects are juicy, they may be directly ground to a pulp, or have their juice pressed from them; or, if they are very succulent indeed, there may be no occasion to bruise them, only directly to commit them to the press, and squeeze out all their juice. But, if their flesh or substance be strong and tough, it may be proper to rasp, shave, or cut them into small pieces; which will be of service in some bulbous roots, and make them yield their juice with the greater ease, and in greater plenty. And, in this manner, onions, turneps, and the like, are to be treated. But, such bulbous roots as those last mention'd, as also mustard-seed, and other alkaline seeds, ought to be made to sprout before they come to be fermented; or else they will rather putrefy than fall into a genuine fermentation. This end may be easily obtain'd, by boiling them a little in water, and soon after drying them by heat; and, unless something of this kind be done, such vegetable substances are apt to afford, in distillation, a neutral spirit, of a nature between an acid and an alkali: but, if they are duly prepared for fermentation, they will all yield an inflammable spirit.

4. The subjects of the third class, viz. the succulent parts of plants, *Those of the third.* need only, in order to their fermentation, be beat to a thick kind of pulp, whilst they are fresh, and mixed with a proper proportion of rain-water, that is, just enough to dilute them; for, if much water be employ'd, the spirit will be the weaker for it.

5. The subjects of the fourth and fifth classes, viz. the fresh, native *The fourth, and fifth.* juices, and weeping liquors of vegetables, with the condensed and unctuous juices of the same, are to be diluted, and let down with rain-water to a due consistence; which is then commonly thought to be obtain'd, when the compound liquor will just keep a new-laid egg afloat; but, some vegetable juices may naturally be of this very density or consistence; and, in that case, they will require no water at all: if any be thicker, or denser, they ferment not so kindly; and, if thinner, or rarer, they afford but a weak spirit. Thus, in order to ferment sugar, treacle, or any common syrup, we first let down the matter with water, to the consistence above-mention'd; and then, if there be occasion, put yeast to it, to quicken the fermentation, and make it proceed kindly.

6. The fermentable bodies of the first class, viz. corn, pulse and *What is required to ferment the subjects of the first class.* nuts, prepared after the manner above described, scarce require any ferment to set them in action, during the summer-season; but in the winter, a greater, or lesser quantity of one is to be used, according to the temperature of the air, or the reigning degree of cold. Thus, to forty pints of a fermentable liquor prepared from the bodies of this class,

we

Processes upon Vegetables.

we may, at a medium, during the winter, add one pound of honey, sugar, manna, or yeast; or, in defect of these, half the quantity of bakers-leaven.

What to ferment those of the second.

7. So likewise, the subjects of the second class; viz. prepared fruits, seldom stand in need of any thing to make them ferment; for, they generally begin to work of their own accord: but, if the weather shou'd prove exceeding cold, or the operation proceed but languidly, it may not be amiss to quicken it, by adding a small proportion of a ferment, as a little yeast, the lees, or mother of wine; or, even a little new wine may serve the turn.

Third,

8. The subjects of the third class also, viz. the prepared succulent parts of plants, require very little ferment, or none at all, to make them work in the summer-season; and no large proportion in the winter: but, in case any at all be required, nothing will prove more serviceable than honey, or sugar.

Fourth,

9. The subjects of the fourth class; viz. the prepared recent juices, and spontaneous tears of vegetables, are so far from requiring any ferment, that it often proves very difficult to restrain or check the fermentation they fall naturally into; especially if the season be warm, and the juices rich: at most, if the weather shou'd prove cold, they need only be set in a warm place to make them work.

And fifth,

10. The subjects of the fifth class, viz. the prepared, or inspissated juices of vegetables, require no ferment at all in the summer, and, but a small proportion in the winter, to set them on working; less than an ounce of yeast to twenty pints of prepared liquor, will usually suffice for that purpose in the coldest season. But, in hot countries, or sultry seasons, these prepared juices, and especially sugar, are, of themselves, apt to fall into too violent a fermentation; which, therefore, ought to be abated by the contrary means.

The general method of committing them all to fermentation.

11. All the vegetable bodies of these several classes, design'd for fermentation, and prepar'd for it in the foregoing manner, ought, together with their ferments, to be committed to casks of oak, already season'd, or imbued with the same kind of fermented liquor, or some other, consisting of subtile and penetrating parts; then these casks, or vessels, having their bung-holes lightly cover'd with a thin, or single cloth, and, being set in a warm place, the liquor will ferment. The mouths of the vessels are thus slightly cover'd over, that the air may have a free passage in and out at them; for, they are here design'd to serve as vent-holes. And these vessels are order'd of wood; because fermentation is never observ'd to be so well carried on in those of glazed earth, or glass; though, on account of their transparency, 'tis sometimes perform'd in the latter, that the phenomena may the better be observed.

Phænomena observed in fermenting liquors.

12. The preparatory business of fermentation, hitherto described, has been carried on by art; but, nature must now perform the rest of the

the work; so that we are here only concerned to observe the phenomena which arise in the operation. When, therefore, any fermentable body is prepared after the manner above deliver'd, and, with its due proportion of a ferment, committed to a large, strong glass-vessel, standing in a warm place, (1.) The whole body of the liquor soon begins to swell, heave, rarify, and send up little bubbles to the top of the vessel, where they burst with an audible noise, and form into froth: now, the liquor, which was before transparent, grows opaque; and a violent uninterrupted intestine motion manifests itself therein. (2.) The parts of the fermenting fluid appear to be incredibly elastic, and the motion of them exceeding violent. Indeed, by means of this property of fermentation, very terrifying and surprizing actions may be perform'd. Thus, if a hundred pints of must were, on some warm day in autumn, to be confined close in a vessel of oak above an inch thick in the sides, and made ever so tight and strong by iron-hoops, yet could not this prevent the working of the liquor; but, in spite of so great a resistance, it wou'd burst the vessel, with a report as loud as that of a cannon. And, therefore, the way to preserve new wine in the state of must, is to put it up in very strong, but small casks, firmly closed on all sides; by which means it will be kept from fermenting: and then it goes by the name of *stum*, and is an excellent ferment. But, if it should happen to fall into fermentation, the readiest, and only way to stop it, is by the fume of sulphur, or something of the same nature. * (3.) A thick skin, or crusty scurf forms itself on the surface, thro' which the elastic or fermenting matter is continually breaking. This crust appears to be the principal cause of fermentation; for, it keeps in, or prevents the spirituous part of the liquor from flying off: and, if it be frequently broken, it puts a check to the fermentation, and will often entirely stop it if wholly taken away. (4.) This skin, or crust, which we now call *flowers* or *yeast*, gradually consumes, and precipitates to the bottom of the liquor; in which case, 'tis called by the name of *faces*, or *mother*; and after this, the fluid above it immediately becomes transparent again, ceases to hiss and bubble, has a very penetrating, pungent, spirituous, or vinous scent and taste, with a mixture of acidity and sweetness: and now the liquor, having undergone the operation of fermentation, is become wine.

The vapor arising from the liquor, during its fermentation, ought not to be approach'd too near, or breathed in too great a quantity, be- A caution to be observed in fermentation.

* Were it not for a knowledge of this property of burning sulphur, the wine-merchants and vintners might frequently sustain great damage from the bursting of their vessels, when the liquor is upon the fret; or, by some alteration in the air, or other accident begins to ferment again; but, the smoke of a little com-

mon brimstone, or a lighted match dip'd in it, and held under a cask of wine that is just ready to burst its hoops, will calm its fury, and make it subside as suddenly as a spoonful of oil, thrown into a large foaming copper of boiling sugar, takes down its head, and prevents the mischief it might otherwise occasion.

cause it is highly poisonous; and, if it proves not mortal, may, at least, render the person apoplectic or paralytic. We have accounts, in the *French* and *German* transactions, of people who were immediately struck dead, by receiving at the nose the fumes that issued from large vessels of wine in the state of fermentation.

And now, if the liquor thus fermented be stopp'd down close, it will begin to work, or feed upon, and digest its own lees, or mother, and at length consume them; in which case we commonly say, the wine begins to ripen; and afterwards, this mother shoots to the sides of the containing vessel, and there appears in the form of an essential salt, which is then called tartar.

*How perform-
able to best ad-
vantage.*

12. The space of time required for finishing the fermentation differs with the subject-matter, the season of the year, the nature of the place, and other circumstances; but it is known to be perfectly perform'd by the several phenomena just now mention'd. As soon as ever the flowers fall to the bottom, the vessel shou'd be bung'd down; otherwise the volatile parts wou'd fly off, and the fermented liquor become vapid and flat. In this state it ought to stand for some weeks in a cool place; by which means it will grow stronger, and more liquid: for during this time, it imbibes and consumes its own *faces*, which abound in subtle spirituous parts, and grows soft, or loses of its acidity, by throwing off its tartar. And the longer it is thus suffer'd to stand, the more strength it gains; or, the more spirit it will yield in distillation. Thus, for instance, malt-liquors newly brew'd afford but a small quantity of inflammable spirit; but, if suffer'd to remain for some weeks, in the vessel, till they become fine and clean, they will yield a much greater proportion: tho', to avoid so great an apparatus of vessels as would then be required, malt-liquors, brew'd in order to make spirits, are seldom kept, but immediately after fermentation committed to the still. And hence we are furnish'd with the reason why all stale, vinous liquors are stronger, and inebriate sooner than such as are new.

*Its physical ef-
fects.*

13. The physical properties of a vinous liquor, prepared in the manner above described, are those which follow. (1.) It will have an inebriating quality, when received into the body: and nothing is properly possess'd of this quality but what has been first fermented. For, if a person should eat ever such a quantity of grapes, or drink ever so freely of must, he might indeed bring a looseness upon himself by that means, but he would not be fuddled. So likewise, to take down large draughts of sweet wort, or the tincture of malt, might throw one into a violent vomiting and flux; but never produce the symptoms of drunkenness. And whatever some pretend as to mandrake, hemlock, poppies, opium, and the like; the effects they have upon the human body are rather stupefying, than inebriating. But, drunkenness is different from stupefaction. An over-dose of vinous liquors first makes a man brisk, lively and joyful, or disposes him to sing, dance, and be merry; at length,
how-

however, his legs will not support him; and, if the fit be violent, he grows furious, raving or paralytic, and so he dies. But opium has not these effects: it brings on a profound sleep; and he who has taken too much of it dies lethargic. (2.) It has the faculty of heating the body; which shews us the propriety of the *Roman* phrase, *incalescere vino*, to grow warm with wine. Nothing appears to cool the body more than currants; yet the wine prepared from them is very heating. The like is to be understood of cherries, and all fermentable bodies, tho' ever so cold; for these will all afford a vinous liquor. (3.) It is inflammable, and will mix with water. (4.) It contains tartar, and affords it after the fermentation is over. This tartar is the essential salt of the vegetable made use of; and differs from the lees, or mother; being resolvable, by distillation, into a water, a spirit, two kinds of oil, an alkaline salt and earth. All fermented vegetables afford it. Must yields a feculent salt, and no tartar; but if once it works so as to become pure wine, it will, in the space of half a year, throw off a clean tartar; which, therefore, appears to be the effect of a perfect fermentation: and accordingly is never obtain'd without it. (5.) It retains neither the colour, taste, nor smell of the specific vegetable from which it was made. Thus we have seen, that rosemary affords a quite different water after it has been fermented, from what it did before. Thus fermented hydromel, malt-liquors, treacle, sugar, &c. yield spirits, by distillation, that cannot be distinguish'd from one another. The grapes of some countries are as sweet as honey, and so is their must before fermentation; yet the wine prepared from either may have little or no sweetness; and sometimes even gain a degree of acidity. It is not easy to believe, that *Rhenish*-wine shou'd proceed from so sweet a grape as it does. (6.) It acquires a somewhat acid and spirituous taste and smell. The taste of honey, or malt, &c. is sweet, and their scent scarce perceivable before you commit them to fermentation; but, after having undergone that operation, they are less sweet, but sharper upon the tongue, and affect the nose with a brisk, spirituous, or vinous odour. (7.) It contains the volatile salt and oil of the vegetable, attenuated, and reduced into one spirit; as may appear by the chemical analysis of a fermented subject. (8.) It renders the oil of the vegetable more volatile than the water. When an unfermented vegetable is distill'd, the first thing that comes over is water, and the next the essential oil; but the contrary is observed after fermentation: for, by that operation, the oil is render'd more volatile than the water; and, therefore, rises first in distillation; having been broke, and ground so fine by the preceding operation, as now to come over the helm, not in its own form, as before, but as the finest, and most volatile part of the fermented liquor, capable of uniting with water.

14. The things that promote or encourage fermentation are, (1.) *By what means promoted.*
Rest; by means of which, the crust on the surface may remain unbroken:

for, 'tis this crust that prevents the spirituous part from flying off. (2.) A free admission of the external air; so that it may come at the internal parts of the fermenting fluid. For, according to Mr. Boyle, if a fermenting liquor be put into his exhausted receiver, the operation immediately ceases. (3.) A moderate degree of warmth; for, too great heat, and too great cold, are the bane of fermentation. And (4.) A proper season of the year; that is, when the vegetables of the same species with that made use of are in their bloom; for, 'tis then their juices are most in motion: accordingly we find, when vines are in the blossom, the wine of former growths will again spontaneously run into fermentation. When these several conditions meet, fermentation is perform'd to the best advantage.

*How check'd,
or moderated.*

15. The things which check or hinder fermentation are, (1.) Too large a proportion of acid salts; such as spirit, or oil of vitriol, oil of sulphur *per campanam*, spirit of salt, &c. Thus, when any liquor ferments too violently, a few drops of oil put into it, or the burning a little sulphur under, or near the vessel, will immediately check and restrain its fury. (2.) An over-proportion of fix'd alkalies; such are salt of tartar, pot-ashes, or saponaceous bodies. (3.) Terrestrial alkalies, as chalk, marl, crabs-eyes, &c. (4.) A close stopping up of the vessel. (5.) A great degree of cold. (6.) A violent degree of heat, or constant motion, so as to thicken the fermenting liquor, and render its parts hard to be separated. (7.) A total extraction of the air. And (8.) A violent compression of the air in the vessel; which Mr. Boyle has shewn will stop fermentation, as well as taking off the air by means of his pneumatic engine.

16. It remains now, that we consider the effect of vinous fermentation, as it regards the production or distillation of inflammable spirits.

PROCESS XLI.

Exhibiting the method of distilling BRANDY, and inflammable spirits, gain'd by FERMENTATION.

The process. 1. **F**ILL about two thirds of an alembic with any vinous liquor, prepared in the manner of the preceding process; lute the junctures, and with a moderate fire, sufficient to make the subject boil, draw off so much as to the taste runs free from the acid part, or will flame away, when thrown upon a naked fire: all which is to be kept by itself, in a close vessel, under the name of brandy, or inflammable spirit.

*How perform-
able to advan-
tage, in juicy
subjects.*

2. In order to make what we call real brandy, to distinguish it from other inflammable spirits, 'tis the general method to take the lees, and other

other feculent, gross, or otherwise useless parts of wine, or such parcels thereof as have been any way damaged or spoiled, together with the least valuable parts of must that can be procured, and throw them all together into one large wooden vessel to ferment, after the manner above set down. And when this operation is finish'd, and the liquor fitted, by time, for distillation, 'tis committed to the alembic, and a proper degree of fire administred, as in the preceding process.

3. But when liquors are prepared from mealy seeds, or other mealy substances, for this process, there are some particular cautions to be observed, *How such as are mealy.* more than are necessary when the fermented juice of grapes, honey, manna, sugar, or the like vegetable juices made into wine, come to be used in it. Thus, (1.) Care must be taken, that the grosser matter of the liquor stick not to the sides, or bottom of the still, where it is apt to run into a cake; which being burnt, or scorch'd by the too near approach of the fire, the oil that was in it, mixing with the spirit, communicates thereto an empyreumatical taste and odour, which is very disagreeable. To prevent such an ill effect, 'tis proper to oil or grease over the bottom and sides of the still with some unctuous material, before the liquor is poured into it. Or else, the matter to be distilled might be stirr'd about with a stick, till the fire below has made it hot; after which, the action of the fire alone will be sufficient to keep all the parts in motion, and prevent the grosser from falling down, or adhering to the still. Lastly, the same good effect may be obtain'd, by first heating the still, or boiling a little water in it; for, after it is thus made hot, or every where bedew'd with the vapor of the water, it will not easily suffer any part of the fermented liquor to grow to its sides so as to be burnt. (2.) The spirit must, as much as possible, be extricated and set free from the more tenacious parts of the liquor; to which purpose it will be convenient to mix and blend all the parts of it well together, before 'tis committed to distillation. A large proportion of the spirit is apt to lodge itself in the feculent part of fermented liquors; witness the lees of wine; which containing it in great plenty ought not, therefore, to be separated from the wine that is design'd to be good. So likewise 'tis very proper, before distillation, thoroughly to mix the sediment, the flowers, and the body of the liquor together; or else to set the whole, close stopp'd up, in a cellar, or some cool place, till it has imbibed its own *feces*; whence it will afford a purer, a stronger, or a more copious spirit, capable of being long kept without any ill scent. And therefore, if any wine, after long standing, is design'd for distillation, it ought not to be drawn off the lees, but shou'd be shook in the vessel before 'tis thrown into the still. (3.) The alembic should not be above two thirds full; that the flatulent, explosive matter of the liquor may not rise into the still-head; which it sometimes does, especially when urged by too large a fire, with so much violence as to beat it off, tho' a great weight be laid on to keep it down; by which accident no small loss has been sustain'd. (4.) A piece of fine linen shou'd be

be spread over the mouth of the alembic, which may be stretched and kept tight, by the head of the still pressing and resting thereon at the juncture. By this means, any foulness, that might otherwise ascend along with the spirit, will be kept back and prevented. This foulness is very apt to rise when the liquor has not been well fermented; and is often the cause of that disagreeable scent we sometimes observe in malt-spirits.

When matters are thus prepared, and all these cautions have been duly observed, we may proceed to distil off our spirit with a gentle fire; which ought to be raised only so high, that one drop may just follow another: and this end may be obtain'd by every now and then applying the hand to the head or body of the alembic, to feel what condition it is in; and regulating the fire accordingly. This caution is more requisite in distilling off spirits from the fermented liquors of mealy vegetables than in others; such as those of grapes, sugar, &c. which may be suffer'd to run in a full stream. The fire shou'd be kept in this equable state for the first hour; but may afterwards, or towards the end of the operation, be raised a little: for, at that time 'twill scarce cause any of the body of liquor to flow over into the worm; and the absence of the more volatile part may not only allow, but require it. All vinous liquors afford their spirit, by distillation, as pure, limpid, and pale as water; but being usually put up into casks of oak, by dissolving the rosin out of the wood it gradually loses of its paleness, and in time tinges itself of that yellowish, or amber-colour we commonly admire in brandy; tho' this is by no means natural to it, only an indication of its age or ripeness. After the spirit is clean drawn off, and the fire a little increased, there always comes over a rough astringent acid liquor, which is nauseous upon the palate, and refrigerating to the body; and lastly, when that has done running, a thick, fetid, empyreumatical oil, which gives a very disagreeable odour to all the vessels it touches. After the distillation is thus, long continued, there remains a feculent pitchy matter, or black mass at the bottom of the alembic, which, being calcined in the fire, affords a fixed, vegetable, alkaline salt, like that of *Tachenius*, and of the same virtues; being the very salt, and almost the same quantity the vegetable would have afforded, if it had never been fermented. And the like happens in all the bodies that ever I knew fermented, and thus examin'd; whence it appears, that fermentation is unable to destroy this salt.

*Nature, virtues
and uses of the
production.*

4. All fermented vegetable fluids distill'd after this manner, and with these cautions, where they are necessary, afford different liquors at different times of the operation. The first that runs off is pungent, penetrating, heating, inflammable, exceeding volatile, or easier to be raised than oil or water; refreshing, inebriating, stupefying, and balsamic, or endow'd with a preservative, or embalming virtue. We call this spirit refreshing, because it proves highly so to persons reduced to a languid state, par-

particularly by a dropfy; and may in that case be conveniently employ'd: though at the same time we must own, that those who use it too freely commonly dye hydropical. 'Tis said to stupefy in this sense only, that if a man under any exquisite pain shou'd take largely of it, till he were intoxicated, he wou'd, for that time, be insensible of his torment. So likewise, when only applied externally, or rubbed upon a part that is in pain, it will give ease, or lessen the disagreeable sensation. And lastly, we say it is balsamic, because of the excellent faculty it has of preserving bodies from corruption, for a very long season. Thus, an *embryo* or *fetus*, the parts of animals, whole insects, flowers, &c. may, without much alteration, or loss of colour, be kept in it for several years. 'Tis an excellent thing to keep anatomical preparations in; excepting only 'tis apt to fret off the *cuticula*. It is also of admirable use in chirurgery, where it happily cures gangrenes, mortifications, putrid ulcers, &c.

5. Thus we have given a short, and exact history of vinous fermentation, as it may be consider'd either physically, medicinally, or chemically; we have drawn out the materials, or subjects of it; exhibited the conditions requisite to fit them for it; the nature of ferments; the methods of working with them; and shewn the specific effect of this grand operation to be the production of an inflammable spirit. Whence we may learn the nature of must, wine, brandy, spirit of wine, and all manner of vinous liquors. According to our doctrine, every liquor fitted and disposed for fermentation is must; every duly fermented vegetable liquor, wine; and the spirit which it affords in distillation, spirit of wine, or brandy. Hence, likewise, it readily appears, that there is no action or operation naturally perform'd in the human body analogous to this of fermentation, since no inflammable spirit has ever hitherto been produced by a distillation of the parts of animals; but, on the contrary, all the distillations which have been perform'd upon such subjects, constantly afforded liquors of a quite different nature. It shou'd seem therefore, that, either the opinion of fermentation in animals ought to be given up; or else a new definition of that word must be advanced.

PROCESS XLII.

Exhibiting the manner of rectifying the Inflammable Spirits obtain'd by FERMENTATION.

The process.

1. **T**HROW the ardent spirit of our last process into a still, (furnished with a worm and refrigerator) whereof it ought not to fill above one half, or two thirds at the most; and with a fire which just causes the subject to boil gently, draw off two thirds of the original quantity: or continue the operation, till the acid part just begins to come over; and by this means there will be obtained the liquor called rectified spirit of wine: an acid water, of an unpleasant smell and taste, remaining behind in the still, with a few spirituous, and some unctuous parts, which were latent in the acid.

Its effects.

2. We see, therefore, that unrectified, inflammable liquors consist of three different parts; a pure spirit, a phlegm or water, and an unctuous acid; the two latter whereof, in some degree, remain even in the purest spirits this process can afford; tho' in a considerably less quantity than before their rectification.

Inconvenience.

3. The spirits obtained from mealy substances, will, notwithstanding this purification, retain something of a disagreeable taste and odour, whereof they may be perfectly deprived by the process immediately following; so as to become undistinguishable from actual spirit of wine, or that prepared from the fermented juice of grapes; and, as some members of the *Royal Society at London* have shewn, altogether as excellent, in every respect, as the most perfect spirit of that kind.

Nature of the production.

4. Many chemical writers assert, that the spirits of this process will raise a conflict with all alkaline bodies; which is true, indeed, of those that have a volatile acid cleaving to them, from which they were not freed by distillation. This acid it is which causes the commotion upon the mixture of such spirits with alkalies: but the spirit itself, properly so called, and containing nothing of an acid, will never exercise the least hostility with alkalies. After the same manner, perfectly pure spirit of wine, prepared with alkalies, will make an effervescence when poured upon acids; tho' not as it is a spirit, but because some parts of the alkali, from which it was distilled, lodge themselves therein. All rectified, inflammable spirits, when perfectly pure, are of an indifferent nature, and neither acid nor alkaline.

PROCESS XLIII.

Exhibiting the manner of preparing ALCOHOL, per se, or perfectly pure Spirit of Wine, from the Production of the preceding PROCESS.

1. **P**UT rectified spirit of wine into a tall, slender cucurbit, and to the ^{The process.} mouth thereof fit a glass-head, made after the manner of an alembic; lute the junctures, and distil with a very gentle heat, in balneo mariæ, so as not to make the water of it boil, or else in a sand-furnace, as long as the ascending vapor continues to trickle in long veins, or rivulets, like oil, down the sides of the glass-head; but desist from the operation as soon as ever it begins to appear in the form of dewy drops: and thus you will have a purer spirit of wine; an unactive, unctuous and nauseous water remaining at the bottom, as in the process immediately preceding. This operation being several times repeated, with the liquor distilled over, will every time give us a spirit purer and purer, and leave a watery part behind. But when no water at all is left behind, the liquor, which then ascends insensibly, without any manifest signs of it upon the glass, either in the form of dew, or oily rivulets, is called alcohol, or perfectly pure spirit of wine.

2. The word *alcohol* is *Arabic*, and originally signifies a thing brought ^{its nature.} to its utmost perfection; 'tis used among chemists in two different senses; and stands for a dry, impalpable powder, as well as this perfect spirit of wine. To dehydrate or purify our inflammable spirits, as much as possible; that is, to separate them from their acid and aqueous parts, which obstinately adhere thereto, there are these two ways. The first is, by gently distilling them, without any addition, in very tall vessels, so that only the fine, volatile part thereof may come over; which is the business of our present process; and this in great measure deprives them of their water, but not of their acid; for that becoming more volatile by repeated distillations, always ascends readily along with the spirit. But the second method, which we reserve for the next process, is calculated to take away this acid part of inflammable spirits; and is called the method of depuration by alkalies.

3. But after all our labour, the spirit will not be entirely free ^{its inconveni-} from acid and aqueous parts. I have myself distilled it seventeen times ^{cies, how to be} over; and still to the last it has left a nauseous liquor at the bottom of the vessel. The operation perform'd in this manner being so excessive tedious, it might save much time, and lessen the expence, if a proper alembic ^{remedied.} were here made use of; a very long, bent, conical tube of copper
S sup-

supplying the place of the still-head, and joining with the worm that passes through the refrigeratory.

Ways of examining the purity of the product.

4. There are three ways of examining the purity of our alcohol. (1.) If it be totally inflammable, without leaving the least moisture in the vessel wherein 'twas burnt, 'tis generally accounted pure: tho' this is no infallible proof; because a small proportion of water might easily be made to exhale by the heat of the burning spirit. (2.) For the same reason, the trial of gun-powder cannot be depended upon: an ardent spirit may be so far inflammable as when lighted up, to burn dry, and at last, set fire to the gun-powder, whereon it was poured; and yet contain some small quantity of water, tho' not enough to keep the powder moist, and prevent its explosion. (3.) But the most certain test of its purity is, if it will communicate no moisture, nor in the least dissolve perfectly dry sugar, salt, or fix'd alkali; but leave them untouched, and no way altered. This criterion is infallible; for were the least drop of water to be harbour'd in the spirit, it would presently be attracted by such saline bodies; as the magnet attracts iron; provided they were thrown into it hot and dry. Thus, if a little spirit of wine be poured upon a few grains of hot and well-dried salt of tartar, placed in some pure vessel; the salt presently imbibes and saturates itself with the aqueous parts thereof, relents, and runs, in form of a liquor. And hence we see the reason why, among the chemists, a dry, fine powder, which will not wet the fingers, is called *alcohol*, as well as perfectly pure spirit of wine.

Its nature, qualities, virtues, and uses.

5. The product of our present process is a very volatile, subtile, inebriating, heating, and totally inflammable liquor, endowed with a balsamic virtue, whereby it preserves bodies from putrefaction; 'tis also an admirable styptic, strongly coagulating all the juices of the human body, and suddenly consolidating wounds, without leaving the appearance of a cicatrix. 'Tis capable of being mix'd with water, oil, and both acid and alkaline salts; from all which it may again be separated by a gentle heat: so that it appears to be the vegetable water of philosophers, incapable of wetting the hands; a property which belongs to no other fluid except, that mineral water, quick-silver. 'Tis very remarkable, that tho' it may be made to mix with all kinds of salt, yet no art can permanently unite it with oil of tartar, *per deliquium*. For tho' you should strongly shake it therewith for twenty-four hours together, till they appear to be perfectly blended; yet as soon as ever the motion ceases, they fly asunder, and continue separate. Nay, I have fastened a mixture of these two to the sails of a wind-mill; by the whirling motion whereof, they have for a long time been successively shook together, without being at all able to unite them permanently. But this is more particularly true of that spirit which has been rectified from alkalies. And of all the liquors afforded by che-

Processes upon Vegetables.

139

chemistry, alcohol is the hardest to work any change upon. This spirit also is so exceeding volatile, that if a quantity of it were to be thrown up into the air of a hot room, scarce a drop thereof would fall upon the floor; but it would almost wholly remain floating aloft; as being the most subtle of all the known sulphureous liquors. 'Tis so inebriating, that if drank imprudently, tho' when it has not been rectified, or in a large quantity, it soon proves mortal, as we frequently find, by coagulating the blood, and inducing an apoplexy, whereof drunkenness is a species. Its balsamic virtue admirably fits for the preservation of animal, or vegetable bodies immersed therein; which it so embalms, as to make them retain their natural appearance for many ages: tho' it does not perform this office so well in some resinous plants; because by dissolving their unctuous parts, it in time deprives them of their colour, and itself thereby becomes thick and turbid. But birds, insects, &c. being first steeped for a few days therein, and afterwards suspended in a fresh parcel, may be preserved, with all their colours, in great perfection. Its styptic quality is so great, that being applied to the mouths of any bleeding vessels, it immediately stops the flux, by coagulating the blood; yet without causing an eschar, as vitriol and other potential cauteries always do. Upon which account we can safely apply it to the nervous, tendinous and most sensible parts of the body, where the common styptics are not to be trusted. When these tender organs are wounded, our alcohol has a wonderful effect; being applied with pledgets of lint. Hence it appears, that pure spirit of wine is not an aperitive, or discutient medicine, as it has been vulgarly supposed; for then it would never coagulate all the juices of the body, as we find it constantly does. Thus it instantly turns the *saliva*, the serum of the blood, the white of an egg, &c. to consistent bodies.

P R O C E S S XLIV.

*Exhibiting the manner of preparing ALCOHOL with
Fix'd Alkali.*

1. **P**OUR highly rectified spirit of wine, or the alcohol of the last process, upon a third of its own quantity of pure, fix'd alkali, first made exceeding dry by the fire; digest them together in a tall, glass vessel, which is to be well shook, now and then, that all the parts of the alkali may come in contact with those of the spirit; then suffer the vessel to rest, and the alkali will fall to the bottom, having absorbed and drank in the acid and remaining aqueous, or oily part; and suffering the pure spirit to rise from it, and float on the top; which may therefore be readily separated.

parated by decantation, or a gentle inclination of the vessel, from the dissolved salt, wherewith it can never be brought to unite. What is thus separated, or else drawn off by gentle distillation, from the fix'd alkali, being again digested upon a fresh quantity thereof, in the very same manner; and the operation repeated till the fixed salt employ'd neither dissolves, nor in the least relents or grows soft, the liquor will then be alcohol, or perfectly pure spirit of wine prepared from fix'd alkali.

Particulars observable there-
in.

2. There are three things in this process, which discover a particular consideration. (1.) 'Tis very remarkable, that the alcohol *per se* of the preceding process, tho' to appearance perfectly pure and simple, is really a compound body. (2.) The alkaline salt seems to dissolve, as it were, *per deliquium*, when the rectified spirit is poured upon it; and also undergoes a very considerable change from the latent acid of the liquor, tho' 'tis not destroyed thereby; but remains capable by exhalation, or calcination, of recovering its own form, and serving again for the same purpose. (3.) A disagreeable kind of oil appears to stick to the surface of the fix'd alkali; which oil has occasioned no small trouble to the chemists, who have not been able to guess from whence it should proceed; for they could never imagine that any oil should remain in the fixed-salt, after it had suffered so great a violence of the fire; and pure spirit of wine, say they, gives not the least signs of any. But I have found, that a certain oil will constantly remain in the acid spirit of guaiacum-wood, tho' it does not at all appear at the first; but becomes visible after the spirit has been kept for some years, and tinges it of a different colour: whence I am led to suspect that the latent acid in spirit of wine contains an oil much after the same manner.

Nature of the
production.

3. The general nature and virtues of alcohol, prepared from alkalies, are much the same with those of alcohol *per se*; except that the former is less perceptible upon the tongue than unrectified spirit of wine; being so light and volatile, as sooner to be dissipated by the heat of that part, than enter the pores thereof by its gravity, so as to excite the sensation of taste. This also, by participating of the addition wherewith it is prepared, retains something of an alkaline nature; so as to cause an effervescence upon mixing with acids. It may, however, be freed from this alkaline part, by gently distilling it over again from a due proportion of oil of vitriol; tho' in this case there is danger that the acid will predominate, so as to exercise an hostility with alkalies, when the spirit is poured upon them. Nor does there seem to be any way yet discovered, of perfectly freeing the two alcohols from their adhering acid and alkali.

Nature of the
operation.

4. Hence we see 'tis much more difficult to purify fermented spirits, than is usually imagined; for how often soever they are distilled *per se*, they constantly carry over with them some proportion of an acid; and when

when rectified from alkalies, some proportion of them too. And I frankly acknowledge that I have no secret way of obtaining these alcohols in absolute purity; nor am I acquainted with *Helmont's* method of resolving them into water and oil. 'Tis true, indeed, that if a common inflammable spirit be poured upon a fix'd salt, some quantity of water, and perhaps of oil too, will be separated therefrom; but I must profess I am unsatisfied whether this can be done in perfect alcohol, which seems to be almost as homogeneous a body as mercury; as it is the most simple indestructible and unchangeable of all vegetable productions.

5. There remain two effects, or productions of fermentation, which we are still to consider; viz. vinegar and tartar. In order to understand the formation of these, we must take notice, that when a ripe vegetable juice, as that of grapes, for instance, is first expressed, it presently of itself begins to fall into fermentation; by means whereof, the saline matter contained therein is disposed to shoot into tartar, and fasten itself in a crust to the sides of the containing vessel; a parcel of grumous *faces*, called the mother of wine, falling to the bottom: upon which the fermented liquor becomes transparent; and if now put up into a fresh vessel, deposits no more *faces*; but still continues to shoot its shining, saline *spicula*, as well upwards as downwards, so as to line all the inside of the vessel therewith. This saline matter, or tartar, is really no more than the essential salt of the fermented juice of grapes; and is never afforded by must. It also contains no inconsiderable proportion of an earthy substance; so that it will not readily dissolve in water. The longer any wine remains in the hoghead, the more tartar it throws off, provided the vessel be kept full; and this whole quantity of wine being at length drawn off, and fresh substituted for it, the crust wherewith the vessel was lined, gradually increases in thickness, so as to render it necessary, or advantageous to break it away. But if, when this tartar is once form'd, the vessel be well and frequently shook, so as to mix the wine and the tartar together, they will begin to ferment afresh, the tartar will dissolve, and become more subtile, and the wine be converted into vinegar; upon which all the inflammable spirit of the wine is so changed, as to appear no more in its own form. The origin, or production of this vinegar we come first to consider.

*Introduction to
the history of
acetous fermentation.*

PROCESS XLV.

Exhibiting the origin and production of VINEGAR, from liquors turn'd into Wine by FERMENTATION.

The process.

1. **A**N *NT* manner of vinous liquor being mixed with its own *faces*, flowers, or ferment, and its tartar, first reduced to powder, or else with the acid and austere stalks of the vegetable from whence the wine was obtain'd, which hold a large proportion of tartar, and the whole being kept frequently stirring in a vessel which has formerly held vinegar, or set in a warm place full of the steams of the same, will begin to ferment a-new, conceive heat, grow sour by degrees, and soon after turn into vinegar.

Its subjects.

2. The remote subjects of acerous fermentation are the same with those of the vinous; but the immediate subjects of it are all kinds of vegetable juices, after they have once undergone that fermentation, which reduces them to wine: for 'tis absolutely impossible to make vinegar of must, the crude juice of grapes, or other ripe fruits, without the assistance of the vinous fermentation.

The matters serving to promote it.

3. The proper ferments for this operation, whereby vinegar is prepared, are (1.) The *faces* of all acid wines. (2.) The lees of vinegar. (3.) Pulveriz'd tartar; especially that of *Rhenish* wine, or the cream or crystals thereof. (4.) Vinegar itself. (5.) A wooden vessel well drench'd with vinegar; or one that has long been employed to contain it. (6.) Wine that has often been mixed with its own *faces*. (7.) The twigs of vines, and the stalks of grapes, currants, cherries, or other vegetables, of an acid and austere taste. (8.) Baker's leaven, after it is turned acid. (9.) And, lastly, all manner of ferments compounded of those already mentioned.

Nature of the production.

4. Vinegar is no production of nature, but a creature of art; for verjuice, the juices of citrons, lemons, and the like native acids, are improperly said to be natural vinegars; because, when distilled, they afford nothing but a vappid water; whereas, 'tis the property of a vinegar to yield an acid spirit by distillation.

A different manner of conducting the process.

5. In *France* they have a different method of making vinegar, from that described in our present process. They take two very large oaken vessels, the larger the better, open at the top, in each whereof they place a wooden grate, within a foot of the bottom. Upon these grates they first lay twigs, or the cuttings of vines; and afterwards the stalks of the branches, without the grapes themselves, or their stones, till the whole pile reaches within a foot of the brims of the vessels.

Then

Then they fill one of these vessels with wine, to the very top, and but half fill the other; then with liquor drawn out of the full vessel, fill up that which was only half full before; daily repeating the same operation, and pouring the liquor back from one vessel to the other; that each of them is full, and half full by turns. When this process has been continued for two or three days, a degree of heat will arise in the vessel which is then but half full, and increase for several days successively, without any appearance of the like in the vessel which happens to be full during those days; the liquor whereof will still remain cool: and as soon as the heat ceases in the vessel that is half full, the vinegar is prepared; which, in the summer, happens upon the fourteenth or fifteenth day from the beginning; but in the winter, the fermentation proceeds much slower; so that they are obliged to forward it by artificial warmth, or the use of stoves. But when the weather is exceeding hot, the liquor ought to be poured off from the full vessel into the other, twice a day; otherwise the liquor would be over-heated, and the fermentation prove too strong, whence the spirituous parts would fly away, and leave a vappid wine, instead of vinegar, behind. The full vessel is always to be left open at the top, but the mouth of the other must be closed with a cover of wood, in order the better to keep down and fix the spirit in the body of the liquor; for otherwise it might easily fly off in the heat of fermentation. The vessel that is only half full seems to grow hot rather than the other, because it contains a much greater quantity of vine-twigs and stalks than that, in proportion to the liquor, above which the pile rising to a considerable height, conceives heat the more, and so conveys it to the wine below.

6. This operation is constantly observed to proceed according to the following rules. (1.) The most generous, unctuous, strong, and full-bodied wines, afford the best and sharpest vinegar; but the weak, thin wines, the most poor and vappid. *According to what rules it constantly proceeds.* 'Tis therefore a great mistake to imagine that vinegar is nothing but corrupted wine, as there are many who persuade themselves. For the spirit of the wine does not fly off in the operation, but is fixed in the acid. (2.) The wine, in passing to the state of vinegar, deposites or throws off a fat oily substance to the sides and bottom of the containing vessel, as also to the twigs and stalks, infused therein; whereby they all appear to be cas'd over, as it were with soap. (3.) Unless this unctuous substance be quite cleared away, once a year, the wine will grow vappid, or turn to a liquor that is neither vinegar nor wine. But this is by no means to be done with hot water, but such as is cold and that with the greatest expedition, lest it should dissolve and extract the acid salts, or ferment, lodged in the pores of the vessels and ingredients; whereby they would become unfit for the purpose.

purpose of making vinegar any longer; for instead thereof, they would then turn the wine into a kind of oleaginous liquor. (4.) The oftner the same stalks and twigs have been used in the making of vinegar, the better they are fitted for the work, and carry it on to the greater advantage; because they every time imbibe a part of the vinegar, during the process, and retain the ferment, lodged therein, for future operations. For which reason they ought not to be thrown away as useless every year, but only to be cleansed of their unctuous matter; which then fits them for farther service. And the same is to be understood of the vessels; which suck in the ferment of the vinegar like a sponge.

*How perform-
able to advan-
tage.*

7. The vinegar prepared, after the manner of our process, from malt-liquors, or beer, provided they be good, differ in no respect from that of wine; tho' we commonly find it weaker: but this is not owing to the nature of the subject, but to its lowness of body and want of strength. Strong beer, well brew'd, and duly fermented, may be made to afford as good vinegar as the richest wines; the inflammable spirit and tartar being also the same in both.

*The Things that
forward it.*

8. The things which encourage and promote the acetous fermentation, are, (1.) Warmth. (2.) Admission of the air. (3.) Frequent motion. (4.) The addition of the hot aromatics; such as pepper, ginger, galangal, &c. which being added to the fermenting liquor, in the proportion of a dram to a pint, will make the vinegar exceeding strong and pungent. But in *France* they never use any spice to their vinegar; because, tho' it makes them stronger, it changes their nature.

*Those that check
it.*

9. This fermentation is check'd by all the same means that restrain the vinous kind, except concussive motion; which is here so far from being an impediment, that it greatly serves to promote and forward the working.

*Its physical ef-
fects.*

10. The effects of our acetous fermentation, when compleatly performed and ended, are, (1.) The production of vinegar; or an acid, volatile, penetrating, unctuous liquor, that makes an effervescence with alkalies, cools the human body, prevents the effects of drunkenness therein, greatly excites and refreshes the brain, spirits, or nerves, and prevents all manner of corruption and putrefaction. 'Tis also attenuating, stimulating, sudorific, diuretic, absterfive, antipestilential, a powerful allayer of inflammations, and a present remedy in apoplectic and lethargic disorders. (2.) A conversion of the inflammable, vinous spirits into such as will extinguish fire. This property is very remarkable. We have formerly seen that all wines, by distillation, afford an inflammable, unctuous spirit; but if again fermented into vinegar, and treated in the same manner, they yield nothing of that kind. And yet the inflammable part of the wine does not exhale in the operation, but still remains in the vinegar. For wine once deprived of its ardent spirit, can never be converted into vinegar: and we constantly

stantly find, that the more the wine abounds with spirits, the stronger and better is the vinegar made thereof. Whence we infer, that those spirits are, by this second fermentation, so fixed and united with the acid of the tartar, as quite to disappear in their own form. That they are actually lodged in the vinegar is plain from hence, that by a certain art, 'tis possible to recover them, or produce ardent spirits therefrom. And this shews us the reason why the vessel above-mentioned, which, in the *French* manner of preparing vinegar, is only half full, is daily to be kept filling up out of the other that is quite full; viz. to extinguish or allay the too great heat in the liquor, by the cool wine of the latter; lest the spirits we are speaking of, should thereby be made to evaporate, after the manner of distillation. (3.) A consumption or disappearance of the matter of the essential salt, or tartar, which is latent in crude vegetables, as we saw in our seventh process, succeeded by an exceeding strong vinegar, after the materials have once disburthened themselves of a very great quantity of oil, which runs from them through the wooden grates, placed near the bottom of the large vessels above-mentioned; upon which the salts presently unite with the aqueous and spirituous parts, and all together turn sour by means of the new commotion: and this being once done, no more tartar is for ever after deposited or thrown off by the vinegar. It might indeed seem probable, that when the oil was once separated from the wine, it should yield the greater quantity of tartar; the direct contrary whereof is true: and yet the tartar does not any way go off, but still remains in the liquor, wherewith it is now more intimately united, and in a greater proportion, on account of the absence of the oil. Whence it is not without reason that vinegar has by the antient chemists been called fluid, or volatile tartar. Indeed we may readily make vinegar from tartar; and constantly find that the more of it we employ in the preparation, the stronger our vinegar proves. In effect, vinegar is no more than the essential salt of wine, made more acid and volatile by a new fermentation, and intimately mixed with the spirituous, aqueous and oleaginous parts of the same. And if tartar be recovered from vinegar, it proves of a different species from that of wine. (4.) A disposition of this vinegar to afford its phlegm for the first liquor in distillation; so that here the spirit appears to be fixed in the subject: as on the contrary it lies loose in wine, and readily comes over first, when this is committed to the still. In wine, the spirit is much more volatile than the aqueous part; but in vinegar 'tis heavier and more closely joined with the dissolved tartar. *Vigani*, indeed, in his *Medulla Chemica*, asserts the direct contrary; and will needs have it, that an inflammable spirit rises first in the distillation of vinegar. But for my own part, I could never find this to be the case. And 'tis probable, that in his experiment he made use, not

T of

Medicinal virtues and uses of the production.

of perfect vinegar, but such as was in a middle state between that and wine; having not yet undergone its due degree of fermentation.

11. We have already enumerated the physical and medicinal properties of vinegar; the most exceptionable whereof are its being unctuous, penetrating, attenuating, or inciding, stimulating, preservative from corruption, antiphlogistic, sudorific, antipestilential, and curative of drunkenness. We call it unctuous, because in distillation it condenses not into drops like water, but trickles down the sides of the vessel in protuberant rivulets, like oil. 'Tis so penetrating as to pass the thickest filtre, without the least diminution of its virtues. Scarce any thing is more attenuating or inciding than vinegar, boiled up with honey, and diluted with a due proportion of water. This, I own, is contrary to the common opinion; for vinegar is generally thought to coagulate rather than attenuate the blood: but on account of its inciding virtue, 'tis highly useful in the small-pox, the plague, and burning-fevers, where the blood and juices are too thick and viscid; or where the humors tend to putrefaction. And when thus prepared, and taken down warm, it likewise proves an useful diaphoretic. Hence *Dioscorides* and *Theophrastus* greatly recommend the use thereof in many acute cases; as particularly in the pleurisy, the *peripneumonia*, distempers from all vegetable or mineral poisons, and the bites of venomous creatures, and even that of the mad dog. Its stimulating virtue appears from hence, that it immediately raises such as are languid, lethargic, and apoplectic, more powerfully than the scent of the spirit of hartshorn, sal-ammoniac, &c. For which purpose we need only dip a linen rag therein, and apply it close to the mouth and nostrils; and by this means I have frequently recovered persons from fainting-fits, and preserved them from falling into the like. I have likewise had experience of the same remedy in lethargic cases, proceeding from taking of too large doses of opium. And it will also seldom fail in the syncope, or even in convulsive and hysteric fits. Its preservative or balsamic virtue is so great, that being used instead of salt, it will for several weeks preserve flesh sweet, in the heat of summer; tho' it be only wrapped up in a linen-cloth, first made wet therewith. And the same virtue it appears to exercise in the human body, when an inflammatory distemper is bringing a general corruption upon the juices. 'Tis so good an antiphlogistic, or so powerful a medicine in cases of inflammation, burning fevers, phlegmons, &c. that possibly we are not possessed of its equal. For this purpose 'twas used in all acute cases, and particularly being mixed with honey, in the *phthisis*, and other consumptions, or corruptions of the body. It also proves a wonderful safe sudorific, being of a refrigerating nature, and therefore highly proper to be given in inflammatory fevers, wherein 'tis so effectual, that when no other medicine can procure a sweat, this will rarely fail to do it. Vinegar also is justly esteemed for its antipestilential virtues, both as a preservative from the first attack of the plague, and the cure thereof, after

it has seized the person. *Sylvius* took two spoonfuls of it every morning, before he visited his patients, in a general plague-season, and all along remain'd perfectly free from every symptom of the distemper: but if he ever happen'd to miss taking his dose before he ventured abroad, he was presently seized with a pain in his head. And *Diemerbroeck* appears to have given it with great success in that violent plague of *Nimmeguen*, wherein as a physician, he was diligently employ'd. Lastly, it is somewhat strange, that a liquor, the basis whereof is wine, shou'd prevent, or remedy the effects of drunkenness; and this the more powerfully, the stronger or more spirituous the wine from whence it was prepared. If a person so drunk with wine, that he is, in a manner, quite stupefied, or render'd apoplectic or lethargic, takes but a spoonful or two of vinegar; he will thereby be immediately rouzed, and brought to himself for a time. And it is very remarkable, that those wines which afford the greatest quantity of vinegar, are less apt to inebriate than others. Thus *Rhenish*, which yields a copious vinegar, is much less apt to disorder the head than *French* wine; tho', by distillation, the former affords more inflammable spirit than the latter.

P R O C E S S XLVI.

Exhibiting the method of resolving VINEGAR into a Water, an acid Spirit, an Extract, an Oil, and a fix'd alkaline Salt.

1. **P**OUR a quantity of vinegar into a glass cucurbit fitted with a proper head, and distil off a fourth part thereof, with a gentle heat; this will prove to be a light volatile phlegm, or water, somewhat acid upon the tongue, and capable of extinguishing fire; and may, by repeated distillations, be almost totally converted into water; tho' it will still retain a few acid particles; whereof it may be entirely deprived, by the addition of a little chalk, which absorbing them all, will leave the water perfectly pure. (2.) If, after one quarter of the vinegar is thus run off, you increase the fire a little, and continue it at the same height, till two thirds of the original quantity is, in all, come over; this second running will be a spirit, somewhat like the former water, but much more acid and ponderous than that: and it will come over in a greater quantity, if the vinegar be not too new, but has been kept for some time. (3.) Urge the remainder with a stronger fire, and a still more acid, heavy, penetrating, and fix'd liquor will rise, capable of extinguishing fire: and this will continue to come over till only a twentieth part of the original quantity of the vinegar remains in the cucurbit. (4.) What now stays behind, at the bottom, appears in the form of a thin syrup, is of a very acid, and fat oleaginous nature, and may not improperly be called the rob, or sapa of vinegar; or if the operation be somewhat

what longer continued, till the remainder comes to the consistence of honey, the extract thereof. (5.) The fire being now augmented as much as the glasses will bear, there will come over first a very strong acid, and afterwards a copious, thick, black, fetid, empyreumatical oil, like that of tartar. (6.) And lastly, what now remains behind is an acid, feculent matter, which, being calcin'd to white ashes in an open fire, will afford a violently strong fix'd alkali.

The cautions it requires.

2. This process proves very tedious, if thus carried on in glass vessels, when, if we go to hasten it, we may chance to break them; 'twou'd be very convenient, for the sake of dispatch, or when a large quantity is to be distill'd, if it were perform'd in a common alembic; but then the head must be of glass: for, the strong acid that ascends in distillation, wou'd presently corrode one of copper, and mixing itself therewith, turn of a green colour. And indeed, notwithstanding the glass-head, the liquor barely by washing the sides, or upper part of the alembic, or body of the still, will carry off particles enough to give it a metalline taste.

The doctrine it affords.

3. It appears from our present process, that the acetous fermentation does not separate, or set free an inflammable spirit from its subject, so as to let it rise in distillation, as we see in the vinous kind of fermentation; but keeps it mix'd, and strictly united with the acid salts of the tartar, so that it now no longer appears distinct, or in its own proper form. But 'tis very observable, that if vinegar be boil'd upon lead, and afterwards distill'd from it in a tall cucurbit, the metal, which is greatly disposed to drink in vinegar, will thereby be dissolv'd into a sugar, or vitriol of lead, which in the operation affords first a water, or phlegm, and afterwards a liquor, and red kind of oil, totally inflammable. Some there are, who pretend that this oil is the sulphur of the lead; but in reality, it proceeds from the vinegar: for, the *Saccharum Saturni* is only the pure metalline part of the lead, associated with the acid of the vinegar into that particular glebe, according to the nature of such bodies. By distillation the vinegar is freed from its aqueous parts, upon which the lead strongly attracts the remaining acid, and strictly unites it to itself; so as readily to let go the oil that was latent in the liquor left behind in the cucurbit. This same oil, which one wou'd not expect to be so copiously contain'd in vinegar, is in wine so broke and attenuated, as presently to rise first in the form of an inflammable spirit by distillation, capable of mixing with water. But in vinegar, the tartareous matter being dissolved in this subtil oil, so fixes it, as to make it entirely disappear, till forcibly extracted therefrom by art; as in the distillation of *Saccharum Saturni*. Vinegar, therefore, is a farther production of art than wine; and appears to be the intimate combination, and strict union of all the active principles that are lodg'd in the subject from which it is prepared; and consequently, its medicinal virtues are greater than those of wine; as being, in reality, no other than an acid, volatile, oily salt.

4. The

4. The virtues of all the acid liquors distill'd over in this process, are *Virtues and uses of the productions.* much the same with those of the vinegar itself, being only of a more penetrating, and volatile nature; because they are, by the operation, deprived of their earthy part. They otherwise differ only with regard to their degrees of acidity, wherein they constantly observe this rule, which is common to all acids, that the greater violence of fire they require to raise them, the stronger they prove; and this holds likewise in the distillation of woods. These several productions are all capable of mixing one with another; and none of them contain any portion of an inflammable spirit. The extract, indeed, will burn in the fire; but this it does upon account of its oily, not its spirituous nature; being, in effect, a strong soap, consisting of sharp acid particles: and, upon calcination, it affords a very corrosive alkaline salt. Nor can stronger alkalies be possibly obtain'd, than what are afforded by vinegar. This extract is accounted an admirable medicine in the plague, and all pestilential disorders, and such cases as proceed from an alkaline putrefaction in the body. 'Tis also good in inflammations, a proper medicine to force a sweat in burning fevers, and in short, one of the best saponaceous bodies we have in acute diseases, upon account of its acidity; but, being of an unpleasant taste, it ought, when taken, to be mix'd up with syrup, sugar, or the like. The spirit of vinegar likewise, which comes over second in our present process, is an excellent medicine, when taken warm, so as to promote sweat, in all cases of poisons, whether external or internal; and particularly good against the bites of venomous animals, as that of the mad dog, &c. And if any of the corrosive, deleterious poisons, such as *euphorbium*, white hellebore, &c. be boiled therein, they lose of their force, and become harmless to the body.

PROCESS XLVII.

Exhibiting the manner of rectifying DISTILL'D VINEGAR, per se, from the Spirit of the preceding PROCESS.

1. **P**UT the spirit of vinegar, or the second and third running of the last process, *The process.* into a moderately tall cucurbit, fitted with a proper head, and distil, with a gentle fire, till one half of the original quantity be come over; all which will prove to be a weak and dilute acid, like the first running of the preceding process; and leave behind in the cucurbit an exceeding sharp and ponderous acid, which we call the rectified spirit of vinegar, and is always the stronger, and more pungent, the longer the operation is thus moderately continued.

2. Hence

its nature.

2. Hence it appears, that the rectification of acetous liquors is the very reverse of that of the vinous. All wines or inflammable liquors totally lose their spirit by boiling; but vinegar becomes stronger by the same means, as being only deprived of its phlegm in the operation; for, the acid salt of the vinegar is too heavy to rise with a moderate degree of heat. We must own indeed, that if fish, flesh, bones, &c. be boil'd together with the vinegar, it thereby loses of its strength; but this proceeds from the gelly of the ingredients: for growing soft, they afford a mucilaginous or unctuous matter, that blunts, or sheathes the points of the acid salts in the liquor; and so render it less pungent upon the tongue. But vinegar, of itself, always increases its acidity by coction, tho' continued almost to dryness; but, after this, it begins to lose of its acid nature, and turn to an alkali.

3. Tho' all that comes over from the vinegar, in the preceding process, shou'd be rectified, or treated in the manner of the present process, not the least quantity of an inflammable spirit wou'd thereby be obtain'd: but the oftener the operation is repeated with the acid spirit, the stronger, and more acid it will grow.

Use of the production.

4. The rectified spirit of vinegar is of use in all the solutions of metals; where such a strong acid is required.

P R O C E S S XLVIII.

Exhibiting the method of rectifying DISTILL'D VINEGAR from METALS, or VERDIGREASE.

The process. 1. **U**PON a proper quantity of common verdigrease pour four times its weight of the strongest, rectified spirit of vinegar, and digest them together, for the space of four and twenty hours, with a degree of heat little lower than that of ebullition; the vessel being, during that time, kept frequently moving; by which means the spirit of vinegar will acquire an exceeding pleasant green colour. (2.) This liquor being decanted clear off from the faces of the verdigrease, let fresh spirit of vinegar be poured thereon, and the digestion be repeated, till the vinegar no longer colours itself, or gains any green tincture from the remaining metalline matter. The several liquors being now all mix'd together, pass under the name of the acid tincture of copper. (3.) This tincture having been filtered thro' cap-paper, is afterwards to be thrown into a cucurbit, fitted with a proper head, and distill'd over with a gentle heat, till the surface of the remaining liquor begins to form itself into a pellicule. But all the liquor that rises by this means will be chiefly aqueous, and prove flat, nauseous, and something acid upon the tongue. (4.) What now remains behind being placed in a cool cellar, will, in a day's time, shoot into fine transparent crystals, of a beautiful green, not unlike the emerald, to the sides of the containing vessel:

vessel; which crystals go by the name of distill'd verdigrease; and that part of the liquor which remains unchanged after the formation of these green crystals, being again exhaled to a pellicule, will now shoot after the same manner; and if the operation be often enough repeated, no liquor will be left untransmuted into the like. (5.) These crystals being thrown dry into a pure cucurbit, or glass retort, and distill'd with degrees of fire, up to the highest that can be given in sand, or till the remaining matter be perfectly dry; there will come over an exceeding ponderous, fat, and violently strong, penetrating liquor, containing a more copious acid, with the least proportion of phlegm, than can by any other art be obtain'd from vinegar; whereof it is the spirit rectified from verdigrease or copper. (6.) What is left behind at the bottom of the cucurbit or retort, appears to be no more than a dry powder; which, by fusion, will return to perfect copper.

2. Verdigrease is here made choice of, as being the strongest metalline *Nature of the addition.* attractive, or magnet of the acid of vinegar we know; and readily turning with it into a metalline glebe, at the same time that it does not in the least destroy, impair, or change its nature; but leaves it perfectly unalter'd, and ready to be drawn away from it again by distillation. Other metals indeed, as well as copper, wou'd do the like, but with more trouble and difficulty; whilst the copper in the verdigrease is already so corroded, attenuated, and open'd by the acid of the grape-skins, wherein it had long lain buried, as to be admirably well fitted for our purpose. Hence we learn, that metals may absorb, or attract some certain acids, and barely lodge them in their pores, so loosely that a moderate degree of heat will serve to set them free, and make them appear in their pristine form.

3. The acid tincture of copper is a remedy of great use in all kinds of ulcers, where gentle corrosives and desiccatives are necessary. And four or five drops of it, in any proper vehicle, are an excellent and immediate vomit, highly proper in case of poisons taken down into the stomach, where a sudden discharge by the mouth is absolutely required, in order to the cure. *Virtues and uses of the productions.*

4. The distill'd verdigrease of our process makes an excellent pigment, that is highly prized by painters; tho' it is attended with one great inconvenience: for as the acid of it flies off, and cannot long be detain'd therein, it in time turns of a brownish colour.

5. Our acid spirit, rectified from the verdigrease, is a perfect vegetable acid salt, tho' mix'd with some particles of copper; which does not absorb or attract the aqueous part of the vinegar, but only the acid salt thereof: whence we have a clear instance, that salts dissolved in aqueous liquors may be separated from them by certain bodies which leave the water behind, but retain the salts without working any change upon them, in such a manner, that they may be thence easily recover'd again by heat. This liquor has greatly embroil'd the art of chemistry. It was

was described by *Basil Valentine*, above two hundred years ago, under the name of *Esurine Vinegar*; and he wou'd needs have it to be the alkahest of *Paracelsus* and *Helmont*. In this opinion he was followed by great numbers, particularly by *Zwelfer*; but he is thoroughly confuted by *Tachenius* in his *Hippocrates chemicus*; who repeats it over and over again, that *Zwelfer's* alkahest is nothing but vinegar. What seems principally to have led them into this error, was no more than their finding that such a spirit poured upon chalk, the *lapides cancrorum*, or crabs-eyes, &c. and distill'd, appear'd to be wholly converted into phlegm. And having thus imagin'd, that this acid was really transmuted into mere elementary water; they hastily concluded, that it was really turn'd into the liquor, or water alkahest. But this was plainly no proper transmutation at all; only a bare separation of the water from the acid part imbibed by the terrestrial alkalies. This rectified vinegar is greatly commended, as an excellent medicine, in case of a want of appetite proceeding from a putrefactive cause; provided it be used only as an ingredient in the preparation of *elixir proprietatis*.

PROCESS XLIX.

Exhibiting the origin and production of TARTAR, from fermented, vinous liquors; by an example in Rhenish-wine.

The process.

1. **T**HE must of Rhenish-wine having been once thoroughly fermented, perfectly changed into wine, and set in a quiet place, lets fall its feces to the bottom of the containing vessel; whilst a clear and pure fluid remains floating above them. (2.) If this transparent purified liquor be drawn off from its lees, into another clean vessel, and suffer'd to rest in the same manner, a parcel of shining, saline, pellucid matter, or spiculæ, will by degrees form themselves all around upon the inside thereof; so as to compose an entire crust or case, which includes, preserves, and keeps in the spirit of the wine, much better than any wooden vessel. This saline matter, thus form'd and concreted, is called tartar: and now, the wine loses of its sharpness or acidity, and gradually becomes more mild, generous and rich. (3.) If the wine be again drawn out of its present vessel, and other new wine of the like kind be poured into the same, this will throw off its tartar sooner, and in a larger quantity; so that by repeating the operation, a case of tartar may be gain'd of a very considerable thickness; so as to fill up a large part of the vessel made use of; or even to serve for a vessel itself.

Nature of the production.

2. Tartar, therefore, is nothing but the pure essential salt of the wine, obtain'd much after the manner of our seventh process; and by no means the feculent part thereof, which always falls to the bottom, and never,

never, like tartar, appears in shining crystals adhering to the sides of the vessel. 'Tis of an acid taste, and constantly appears of the same colour with the wine which affords it. Thus, that of *Rhenish* is white: and that of claret red. But no wine will afford it, unless it be perfectly pure and fine. 'Tis very difficult to dissolve in wine, and requires the heat of ebullition, and twenty times its own quantity of water, before it will perfectly unite therewith; which are uncommon properties, considering it was at first latent, or imperceptibly dissolved in the wine, which wou'd then readily mix with water. Hence it is, that wine contain'd in a hoghead well-lined with tartar, never penetrates through it, but keeps fresh, good and spirituous, for several years successively.

3. The origin of the word *tartar*, so laboriously treated of by *Paracelsus*, comes at length to this. We find it deliver'd by *Moses*, that the ^{name.} *earth was cursed*, after the fall of *Adam* and *Eve*; but more particularly, the vegetable kingdom thereof. That is, says *Paracelsus*, all manner of vegetable subjects had then a certain force given them, far superior to, or unconquerable by that of animal bodies; whence it became impossible for us to digest and assimilate some one part of them into our own nature. And observing, that there was a certain stone contain'd in, or afforded by all kinds of wine, or fermented vegetable juices, not easily dissolvable in any common liquor, he wou'd needs have this stony matter to be the *curse*; and accordingly term'd it *Tartarus* or *Gehenna*; at the same time asserting it to be the immediate cause of the gout, stone, all obstructions in the *viscera*, and other disorders. And the same opinion was likewise entertain'd by *Basil Valentine*, and many other chemists besides.

4. The medicinal virtues of crude tartar are very considerable, as ^{Virtues and uses} being preferable to the cream, or crystals thereof; on account of the ^{of the produc-} virtue it has to cleanse the *prima via*, and cure the diseases to which ^{tion.} they are subject. But, of itself, without some farther preparation or assistance, it can scarce enter the second passages, or lacteals, by reason of its grossness, difficulty of solution, and the want of a sufficient heat, and quantity of liquor in those parts, to break its texture, and run it into a fluid. Tho' we must acknowledge, it may be perfectly dissolved, if it happens to meet with any strong alkali; and therewith compose a penetrating soap, which may easily enter the mouths of the lacteals, cleanse their passages, and break away any obstruction that may chance to be form'd therein. Tho' when it is thus mix'd, suppose with the bile, or other juice, it no longer acts as tartar, but as a neutral salt, or saponaceous body. And tho' by this means, it may be render'd an exceeding penetrating, and subtile medicine; yet when barely dissolv'd in water, it proves so gross, as not to pass a flannel-strainer. In this state, however, it admirably serves to disburthen the intestines of their load, without disturbing any other part of the body; for which reason it ought to be highly valued: and in this respect it does not fall

short of tamarinds; these two being the principal medicines that work after this peculiar, gentle manner. It likewise cures all distempers arising from putrefaction, a lentor and inactivity in the intestinal tube. To answer these ends, it is to be given in the quantity of six drams, or an ounce, in broth, water-grewel, or the like. This crude tartar being, as we have already observed, the native salt of wine well-fined, has no impurities mix'd along with it; for which reason it is, that its medicinal virtues exceed those of cream, or crystals of tartar; for these are no more than crude tartar boil'd and dissolv'd in water, and suffer'd to shoot afresh; by which operation, as the tartar is not purified, so it loses of its efficacy; the subtil spirit thereof being made to evaporate by the heat. *Angelus Sala*, an *Italian* physician, who, for some time, practised at the *Hague*, and of whom *Mr. Boyle* very justly says, that he was a candid chemist; has wrote an entire treatise upon tartar, entitled *Tartarologia*; in which he frankly discovers all his secrets upon that head, to the great satisfaction and advantage of physicians. In this book he tells us, he found it an excellent remedy in the colic, hysteric disorders, and stubborn obstructions of the intestines; and particularly in such cases of the gout, and other disorders as proceed from free living, or the use of rich wines and a high diet. And this he ingenuously acknowledges to have been his grand *arcanum* in these cases; being given in the quantity of an ounce, for three or four mornings successively. By this means he gently purged his patients, brought down their flesh, kept them laxative, and freed them from their distempers, without raising any new disturbance in the blood, or causing the least disorder in their bodies; for this admirable medicine, by stimulating only the glands of the intestines, derives a flux of humours into them, which it afterwards discharges by the *anus*, in the most calm and kindly manner, without leaving a prejudicial costiveness behind it.

P R O C E S S L.

Exhibiting the analysis of TARTAR, or its resolution, into a water, a spirit, two kinds of oil, and a fix'd alkali.

The process.

I. **F**ILL two thirds of a glass retort with small entire pieces of choice white tartar; slightly lute on a receiver, and in a sand-heat cautiously administer the several degrees of fire. The subject will soon change its white colour to a brown, and the liquor that first comes over will be a copious, tart, bitterish, and penetrating water, with a mixture of spirit. (2.) Upon augmenting the fire to the second degree, there will arise a whitish vapour, which turns to a more yellow, and bitter, but less acid spirit than what at first came over; together with a quantity, of a light, thin, black, penetrating oil, of a somewhat bitterish, but grateful taste. (3.) By a fire of suppression, a thick, black, strong, fat, fetid,

fixed, and ponderous oil will be made to rise, and sink thro' the former liquors to the bottom of the receiver. (4.) There now remains behind an inflammable mass, that will constantly appear blackish in the retort, tho' urged with ever so violent a fire, of a fiery alkaline taste, and disposed to run in the air into oil of tartar, per deliquium; tho' tartar itself proves difficult to dissolve in water. But by being calcined in an open fire, it turns to a white ashes, which diluted in water, filtered and exhaled, yield a salt of tartar, that becomes blue, brown or red, by fusion, as formerly mention'd of fix'd alkalies.

2. The juncture of the retort and receiver is here order'd to be but slightly luted, because there is otherwise the greatest danger of their bursting to pieces in the operation; tho' they were ever so large or capacious. For even the water which rises first is so exceeding subtle, penetrating, and forcible, as either to escape thro' a close and glutinous luting, or else to burst it, or to break the strongest glasses. But the oil that comes over second is still more subtle and powerful; so that tartar cannot possibly be distill'd without breaking the vessels, unless it be suffer'd to transude thro' the luting, as it constantly does, be the luting what it will, like water through a sponge. Indeed, it is the most penetrating thing that chemistry can produce; as the elder *Helmont* long ago observed. In our present process, therefore, 'tis safest to use the common lute, and not that of the philosophers, as 'tis called, which will suffer no acid spirit to pass it. Hence we see, that waters, spirits, acid salts, and vegetable oils, may, after a wonderful manner, lie close and latent in a dry form; and that all the essential salt, and native oils of a plant are not render'd volatile by vinous fermentation; whilst the acetous kind attenuates, dissolves, or consumes the whole thereof, and, together with the oil, turns the salt into a volatile, unctuous, saline, or acid liquor. Whence vinegar becomes a more powerful solvent than wine, which is in great measure spoiled and robb'd of its native salt or tartar; the more whereof it deposits, the softer it always proves; so that at length, having thrown off all its saline parts, it becomes that mild and oily liquor, call'd by the old woman in *Plautus*, *vinum edentulum*, toothless wine; as retaining no manner of pungency, or biting sharpness upon the tongue; which is always owing to the tartar contain'd in the wine. * This process likewise shews us, that we can form no true judgment of the nature and properties of a salt, from what remains thereof after distillation. Tartar, of itself, is an acid salt, and raises an ebullition with alkalies; but what it leaves behind, upon distillation, is perfectly of an

* Whoever has tasted of that old-hock in the great cellar at *Heidelberg*, which is there said to have been preserved for several ages, will have a very good notion of this *vinum edentulum*; as being perfectly smooth, flat, and oily upon

the tongue, without any thing of that brisk flavour, or relish, to be found in the wines of later growths; so that a man can hardly be persuaded 'tis wine he holds in his mouth, when he goes to taste it.

alkaline nature; tho' doubtless it did not exist under that form in the vine; and tho' but little acid comes from it in the operation.

*Virtues and uses
of the produc-
tions.*

4. The oil which rises along with the spirit of our present process, is recommended by *Paracelsus* and *Helmont*, as an extraordinary remedy for cherishing, restoring, and relaxing the limbs contracted by cold; and for resolving the gross, concreted juices of the body, and even those hard knots occasion'd by severe fits of the gout. For which purposes it may be better fitted, by rectifying it along with the oil that runs off third; whereby it will be freed from a copious earth contain'd therein. This oil also has a wonderful property of recovering the lost odour of perfumes; or of increasing and fetching out this scent, by being mix'd therewith in a very small proportion: and I knew a certain artist, who had a peculiar way of thus bringing musk, ambergrease, and the richest sweets to themselves, with a few drops of the fetid oil of our present process; by which means also he greatly added to their virtues. The same thing has also been practis'd, to very great advantage, in the Duke of *Holstein's* court. And the method of it seems agreeable enough to the common experiment of suspending such parcels of musk, civet, ambergrease, &c. as have almost lost the sweet scent for which they are valued, in a jakes for some time; whereby they are again brought to be perfectly odoriferous.

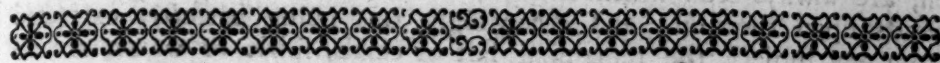
*Advantage of
the process.*

5. The salt of tartar prepared after the manner of this process, may be obtain'd to greater advantage, and in a much larger proportion than in the common way of calcining it in an open fire. For when the tartar has been resolved into the several parts above-mention'd, it will, at last, by calcination, yield the strongest alkaline salt we know, and the fittest for chemical uses.

*Introduction to
the chemical
uses of the pro-
ductions of fer-
mentation.*

6. Having seen the effects of water upon vegetables, as applied thereto with the assistance of fire, and found, that it will dissolve their aqueous, saline, saponaceous, and gummy parts; it remains that we shew the effects of spirits, salts and oils upon the same. There are some vegetable substances, or bodies of a doubtful nature, that is undetermin'd as to the kingdom they belong to, very difficult to dissolve in spirit of wine, or the purest alcohol; such is amber, for instance (which appears to be a kind of fossil bitumen, though refer'd by us to the class of vegetables) myrrh, gum-guaiacum, gum-lac, gum-juniper, gum-hedera, dragons-blood, &c. which, tho' upon account of the grossness, or peculiar tenacity of their parts, they are not easily resolvable, may yet be made to afford their tinctures, by the due application of alcohol and fix'd alkali, together with the assistance of fire. On the contrary, there are others of a soft texture, that may readily be dissolved in spirit of wine, by a gentle heat, without the help of any alkaline salt, which would rather serve to alter their natures, or impair their virtues, than open their bodies, and prepare them to give out their tinging parts to the *menstruum* with greater advantage. Such are all the purging roots, as those

those of jalap, turbith, hermodactils, &c. and the inspissated juices, as opium, euphorbium, benjamin; but particularly, all those that contain a copious balsam, the tinctures whereof are prepared in the following manner.



USES of the PRODUCTIONS OF FERMENTATION.

PROCESS LI.

Exhibiting the manner of extracting TINCTURES, with RECTIFIED SPIRIT OF WINE per se, from resinous vegetables of a loose texture; such as JALAP, SCAMMONY, and BENJAMIN.

1. AVING reduced crude jalap-root, for instance, to powder, The process. put a proper quantity thereof into a tall vial, and pour upon it as much spirit of wine, once rectified, as will rise two or three inches above it: keep the liquor gently boiling for four and twenty hours in a sand-heat, or wooden furnace; and afterwards, let it stand for some time, in a quiet, cool place, that the feces may fall to the bottom, and leave a fine transparent, unctuous liquor, richly impregnated with the virtues of the subject, of a colour between a yellow and a red, floating above them. This liquor is the tincture of the jalap; and shou'd be gently decanted from the sediment, by a gradual inclination of the vessel.

2. 'Tis usually very improper to filtre any of these tinctures in order to make them fine; because the resinous or gummy parts thereof will *A caution is to be observ'd therein.* stay behind on the paper; and seldom all run through a strainer, the pores whereof are any thing small or close.

3. The

Its nature.

3. The tinctures prepared after this manner are constantly found of a reddish colour. Thus, in our present process, tho' the powder of jalap is almost white; yet the tincture appears of a deep yellow, copiously mix'd with red. And thus likewise, the tinctures of opium, benjamin, or any of the blackest, or whitest bodies, provided they abound with oil, are always red: which is a plain indication, that their colour depends upon their oil; and accordingly, this being perfectly extracted from any subject, the remaining salt or earth, spirit or water, are always white or colourless. * The greatest part of these tinctures also turn white or milky, upon mixing with warm water; which proceeds entirely from the rosin they contain; and is the same thing that ascends, mix'd with oil, in the distillation of the waters of vegetables. But the tincture of saffron, and some other very subtile bodies, will retain their own red colour, when water is poured to them; which is a plain argument, that their oil is of a much more subtile nature, than that of the tinctures we just now mention'd.

Virtue and uses
of medicinal
preparations
obtain'd by its
means.

4. The tincture of benjamin, prepared according to this process, and mixed with a proper, or an equal quantity of fair water, turns into a white liquor, which, upon account of the use made of it, goes by the name of virgin's milk; † being frequently employ'd as an innocent cosmetic by the fair sex. And indeed, by repeated application, it will soften the skin, dilate its pores, and, by degrees, take away spots, or freckles in the face, and give a fine complexion. It has also a very grateful aromatic flavour; and, upon account of its fine attenuated rosin, proves an admirable balsamic medicine in coughs proceeding from the taking of cold; being used along with some proper syrup, as that of violets, diacodium, or the like, in the quantity of twenty drops for a dose, to be repeated occasionally.

Whence they
proceed.

5. The virtues of these tinctures arise partly from the spirit of wine employ'd in their preparation, and partly from those peculiar to the juices of the subject, which, so far as they are of a resinous nature, go to compose the tincture; without any mixture of their saline part, unless the *menstruum* were a low, or phlegmy spirit, capable, by its aqueous parts, of dissolving salts. Hence the tincture of jalap, taken in

* Sir Isaac Newton endeavours to prove, that bodies refract the rays of light which fall upon them, in proportion to the sulphur they contain; and by particular experiments has found, that those wherein the sulphureous principle abounds the most, refract them the strongest.

† The common *lac virginale* of the shops, is a liquor of a different nature from this, tho' used for the same purpose, but with much less safety; being prepared of alum-water and litharge boiled in vinegar, the mixture whereof makes an imperfect kind of white liquor;

which being very cooling, astringent and repelling, is an improper cosmetic, and may do mischief, when applied to the face to strike in pimples, or cuticular eruptions, by blocking up the pores, checking the natural perspiration of the part, and throwing back the matter into the blood; and thus sometimes prove the cause of fevers, or other distempers; which inconveniencies are avoided, by the use of spirit of benjamin, made milky with fair water; especially, if preceded, or accompanied with proper evacuations.

the

the manner we shall hereafter mention, is one of the noblest hydrogogues hitherto discover'd; which, had *Hippocrates* but known, he wou'd have highly esteem'd.

6. 'Tis here to be carefully observ'd, that tinctures of these resinous vegetables of a lax texture, especially if they abound with salt, are sometimes drawn to the best advantage, with weak spirits, or aqueous menstruums. For sometimes the purgative virtues of such bodies reside in their saline parts; upon which account, 'tis often very proper to let down our spirit of wine with water, in order to obtain the full force and virtue of simples; or sometimes even to boil them in nothing but pure water. The alcohol of wine, we see, dissolves only the resinous and oily parts of vegetables, and leaves the saline untouch'd; which, however, are eagerly taken up by water. So that, in some cases, it may be highly disadvantageous to employ pure alcohol in the extraction of tinctures. This is an observation of very great moment; for which we are beholding to some industrious members of the *Royal Academy at Paris*. And hence we may establish it as a rule, that water is the proper menstruum for saline subjects, alcohol for such as are resinous, but a diluted spirit of wine for those that consist of saline, as well as unctuous parts. Sena, by being infused in high rectified spirit of wine, communicates nothing, or very little, of its purgative virtue thereto; whilst water wou'd extract it fully. On the other hand, scammony wou'd scarce open at all to water; but is totally dissolved in spirit of wine. And our present subject, jalap, whose cathartic virtue resides both in its resinous and saline part, requires a spirit lower than alcohol; tho' it must, however, be once rectified, to deprive it of its acid, which wou'd otherwise greatly obstruct, or weaken the purgative power of the root.* And hence we are shewn the reason why the rosin of jalap, which is extracted from the subject by pure alcohol, proves less cathartic than that gain'd from it with a weaker spirit. For even after the alcohol has extracted its rosin, and saturated itself therewith; an aqueous menstruum, poured upon the remains, will fetch out the salt, which is also purgative, and ought to be mix'd with the rosin, to gain the full force of the subject.

* 'Tis a desirable thing in pharmacy, to be able to suit the menstruum to the ingredients, so as to extract the parts required, without any mixture of those that are foreign to the design of a composition. This cannot sometimes be done but by the assistance of two or three different menstruums, put to work upon different ingredients. But the common dispensatory-writers have so little regard to these cautions, that 'tis generally much safer to trust nature, and take the crude simples as she affords them, than rely upon common preparations, contrived at all adventures, or without a due knowledge of their nature, the different parts whereof they consist, or how to extract the particular virtues required from them. By which unskillfulness in pharmacy, we sometimes see the purgative simples deprived of their natural correctors, and sent with their drawn *spicula* into the body, to stab and wound the intestines, without the least opposition.

Hence

The Doctrine it affords.

7. Hence we may inform ourselves, that inflammable spirits of wine extract from vegetables those parts only, which by distillation are made to come over and appear in the form of oil; and which, when they spontaneously ouze out from plants, and thicken or grow hard by the sun's heat, go by the name of balsams or rosins. So that the tinctures of vegetables appear to be no more than a mixture of their oily and spirituous parts.

PROCESS LII.

Exhibiting the manner of preparing Tinctures with ALCOHOL, per se; by an EXAMPLE in SAFFRON.

The process.

1. **P**UT of the finest dry saffron into a very tall glass-vial, made perfectly pure and dry; pour upon it about four or six times its own quantity of alcohol of wine, rectified per se, and then digest them together, with a gentle heat, for eighteen or twenty hours; whereby the alcohol will be tinged of a very beautiful yellow. When the vessel is thoroughly cooled, gently separate the tincture from the saffron, pour a fresh parcel of alcohol upon the remains, and digest as before, till the spirit has imbibed all the yellow part of the subject, and leaves only the stamina thereof, perfectly white, at the bottom of the glass, and deprived of all their natural taste and scent. Then the several gold-colour'd liquors, being mixed together, give the tincture of saffron in great perfection.

Its Nature

2. This process is to be perform'd with alcohol, rectified per se, and not that distill'd from fix'd alkali; because the latter wou'd destroy the tender structure of the subject, or change its nature; whilst the perfectly pure and unmix'd inflammable spirit, here employ'd, barely extracts its oily or sulphureous part, colours itself therewith, and thereby becomes enrich'd with the taste, odour, and virtues of the saffron, yet without partaking of its salt; which can never be dissolved by alcohol.

Doctrine.

3. If this tincture be drop'd into water, it does not make it appear any way thick or turbid; but barely turns it of a fine yellow, or gold-colour: which certainly proves that the oil contain'd in the chives of saffron, is too much attenuated, or broke too fine, to form or concrete into rosin.

Medicinal virtues and uses of the production.

4. The medicinal virtues of this tincture of saffron are very many; and when properly used, it proves an excellent cordial, as containing a very fine and subtile oil. But prudence is required in the administration; otherwise it may easily become poisonous. If a person, unaccustom'd to the use of saffron, should take but a single dram of the

ex-

extract that may be prepared by exhaling away this tincture over a very gentle fire; he would first, for a few days after, appear wondrous joyful, and then run into a mirthful kind of madness, attended with an almost continued fit of laughter; but at length he would fall into a lethargy, or an apoplexy, to the no small danger of his life. I myself knew a worthy professor here at *Leyden*, who falling into a fit of hypocondriac melancholy, attended with a great dejection, or sadness of mind, and having the constant use of this tincture prescribed him by his physicians, was thereby rendered perfectly childish or silly; and narrowly escaped with life.

P R O C E S S LIII.

Exhibiting the manner of preparing TINCTURES, with Alcohol and Fixed Alkali, from subjects of a strong texture, or hard, glutinous nature, such as Amber, Myrrh, Gum-lac, &c.

1. **R**EDUCE myrrh, for example, that is not too fat or unctuous, into *The process.* a fine powder, and mix it up well with oil of tartar, per deliquium, into a soft kind of paste; then dry it in a glazed vessel, or one of glass, over a gentle fire, till it becomes a dry powder again: place this powder in a cool cellar, and there suffer it to run by the moisture of the air; dry it again, and repeat the process with fresh oil of tartar, till all the myrrh is at length so opened, that it will perfectly dissolve in alcohol of wine. (2.) Upon the powder thus prepared, gently dry'd, and put into a very tall, chemical vial or bolt-head, pour enough alcohol, rectified from fix'd alkali, to swim three or four inches above it; and then let them boil together, over a soft fire, in a wooden furnace, for the space of four and twenty hours; after which time, the vessel being suffered to cool of itself, gently decant the liquor from the fæces at the bottom, and you will thus gain a fine, transparent, tincture of myrrh.

2. This is the best method I am acquainted with, of obtaining *its excellence.* tinctures from hard, gummy bodies, remarkable for the tenacity of their parts; and what I found to be better than any of the other numerous ways which I have tried; as expeditiously affording a perfectly beautiful and transparent tincture, highly saturated with the unctuous parts of the subject; whilst many of the other methods require a longer time, and are apt to foul the tinctures, and make them turbid. By this means we can presently draw the tincture of amber; which, in *Helmont's* method, requires a week's digestion to obtain. And thus, as we have seen, myrrh may be easily dissolved in alcohol of wine; tho' there are many who pretend that it can never be brought to afford any tincture at all: so that they would

have us believe that *Elixir Proprietatis* is nothing more than a tincture of the aloes and saffron, without taking up a grain of the myrrh prescribed in its composition. This is always to be observed as a general rule in the present process, that the harder the subject is to dissolve, the finer it must be ground, the oftner moistened with the oil of tartar, dry'd and run into a liquor, and again the longer digested with the spirit; whereby at length the tenacity of its parts will be entirely destroy'd, and its texture broken. But, except in extraordinary cases, when the course of operations has been thrice repeated, the body will be sufficiently opened to dissolve in the spirit. Thus even gum-hedera, tho' so difficult of solution, will be so penetrated, have its parts so separated, and its vinulum so broken and destroy'd, by going three or four times through the circle, as readily to dissolve in alcohol of wine. The glass vial, or bolt-head, used in this process, is ordered to be very tall; so that if the neck be slender as well as long, it may well enough be kept open at the top, without danger of the spirit's exhaling at the mouth thereof; because in such vessels the air will perform the office of a stopple, and keep in the fine vapor that arises in the operation.

Nature and medicinal virtues of the productions thereof.

3. Whatever is extracted by the menstruum from the subjects of this process, is totally inflammable: which lets us see the justness of the establish'd rule in chemistry, that alcohol of wine takes nothing up from vegetables, but what is of its own nature; and therefore principally dissolves only their oily, resinous, and spirituous parts. The virtues of these tinctures are to be learnt from the natures of the several subjects that afford them, together with that of the spirit; tho' they are here greatly exalted by the operation, as well as the menstruum. In general, they are balsamic, vulnerary, healing, corroborating, exhilarating, deobstruent, and, when taken in a large dose, purgative. They greatly resist putrefaction in the body, brace up the slackened nerves, serve to drain off superfluous humors, and cure distempers proceeding from a cold, viscid, or pituitous cause in the juices, or inactivity on the side of the vessels; and are also of very great use in various cases of chirurgery. They may conveniently enough be taken with a glass of *Spanish* wine, or the like, soft, spirituous vehicle, in the quantity of a dram or two, twice or thrice a day.

4. Thus the tincture of gum-lac, prepared after this manner, is the best medicine hitherto known in that species of the scurvy which proceeds from putrefaction, where the vessels are weak, infirm, or in part eat away by the acrimony of the distemper, and the breath smells fetid. 'Tis also excellent in case of the rickets in children; being given in the quantity of a few drops, twice or thrice a day. The gum itself has a bitter flavour, is somewhat astringent upon the tongue, and contains an oil, that it will not readily communicate to spirit of wine by coction; but may be advantageously fetched out by the treatment above-mentioned.

5. The

5. The tincture of amber, prepared in the manner of our present process, is a noble medicine in hyfteric and hypochondriacal disorders, lax constitutions, and where the nerves are weak and unbraced; as likewise in all cases where a purulent matter is formed in the body, or any foul, internal ulcer wants to be cleansed, in the epilepsy, and the *fluor albus*; upon all which accounts it was justly recommended by *Helmont*, who greatly increased his reputation by its means. And I myself knew a physician, who became very famous from this single medicine; and continued in great repute so long as he kept it a secret. It may be taken in the quantity of a hundred drops, thrice a day, in any convenient vehicle. But in putrid fevers, or any other acute distemper, it ought not to be used; because it would there do mischief. 'Tis very serviceable, being applied externally to ulcers, which it excellently deterges when they are foul, and especially such as are venereal. And some have recommended it as a great preservative, to procure a continuance of health and long life.

6. Our tincture of myrrh is likewise an admirable medicine, in all cases, where both the *prima* and *secunda via* are to be opened, any corrupt humor to be deterged, or the juices stand in need of a balsam to preserve them from putrefaction. Hence it proves highly serviceable when ulcers are seated in the kidneys, lungs, *uterus*, &c. 'Tis of wonderful efficacy in all the distempers peculiar to women, that proceed from a watery cause, or too great a laxity of the vessels; as particularly in that exulceration of the vessels which causes the *fluor albus*. In the venereal disease 'tis a very effectual remedy, as strongly resisting and cleansing away the putrefaction which that distemper brings upon the fluids and solids. It also proves of service in tertian and quartan agues. Its external uses in chirurgery are no less considerable than its internal in other parts of medicine. It powerfully deterges fistula's, and foul, sinuous, or venereal ulcers; and when the bones are carious, and require exfoliation, as frequently happens from the venereal taint, no better remedy can be employ'd. In the scurvy, attended with a corruption of the gums, and a loss of their substance, it serves to stop the growing evil, and preserve them from farther injury. In fine, the medicinal virtues of myrrh have ever been esteemed so great, that all antiquity was employ'd in finding out ways to resolve it, tho' not with any extraordinary success; for 'tis exceeding difficult of solution: and if taken into the body in form of a powder, it is not digested by the force thereof, but comes away again crude, as it was received. Hence *Helmont* tells us, in his treatise of *Long Life*, that he who can render myrrh soluble by the body, has the secret of prolonging his days. And, indeed, there seems to be some truth in the assertion; since it cures the most desperate ulcers, and prevents all manner of putrefaction in the human body and animal substances. Thus, were a bird, for instance, or any other small animal, to be dipt several times successively in our tincture of

myrrh ; it would soon be perfectly penetrated or embalmed thereby, and turned to a kind of *Egyptian* mummy, capable of remaining entire for numerous ages ; which is an operation that in the common way of embalming cannot be so well performed in the space of several months.

P R O C E S S L I V.

Exhibiting the manner of making CATHARTIC POTIONS, with the productions, or resinous Tinctures, of the fifty first PROCESS.

The process.

WITH any resinous, purging tincture, prepared after the manner of our fifty first process, mix twice its own quantity of some purging Syrup ; and you will thereby obtain an excellent cathartic potion, that strongly and suddenly discharges aqueous humours out of the body, and may be given to great advantage in cold or leucophlegmatic constitutions.

Virtues and uses of the productions,

2. Thus if three drams, or half an ounce of the tincture of jalap be mixed up with six drams, or an ounce of the syrup of buck-thorn, syrup of rhubarb, or the solutive syrup of roses, prepared either with or without senna ; it excellently moves, and suddenly draws off the collected lymph in a dropsy, and discharges it by stool. The like may be said of the tincture of scammony, tho' this is of a stronger, and somewhat hotter nature ; and the same holds true of all the resinous cathartics, turbith, hellebore, colocinth, hermodactils, &c. But a proper regimen is to be observed, when such violent medicines are taken. These resinous tinctures should never be mixed up along with waters for exhibition ; because by this means their rosin would be precipitated, and, in swallowing of them down, stick to the the inside of the mouth, so as to prove very nauseous, and exceeding difficult to get off.

CHEMICAL HISTORY of ROSINS.

PROCESS LV.

Exhibiting the manner of obtaining ROSINS from the productions of the fifty first and fifty third PROCESSES.

1. **W**HEN the resinous tinctures of our fifty first and fifty third processes have, by long standing at rest, in a cold place, perfectly purified themselves, and let fall their faeces to the bottom of the containing vessels; if any one of them be distilled with a gentle heat, in a glass retort and receiver, till three fourths of their original quantity is come over; and clear, cold, rain-water be pour'd upon the remainder, in the proportion of four or six to one; the whole mixture will immediately turn milky, thick, and turbid; upon which a yellow, unctuous, and soft clammy matter will be precipitated, or let fall to the bottom, as being by the water set free from the alcohol wherein it before remained dissolved. (2.) Let the whole of this mixture be distilled again, or committed to a low and wide glass vessel, and exhale away over a slow fire, till either the ascending vapor, when condensed, ceases to run in oily rivulets, or till all the spirit is evaporated, and the remaining water becomes clear, which being poured away when cold, the yellow, tenacious, unctuous substance is found fix'd to the sides and bottom of the vessel. (3.) Pour fresh water upon this viscid, adhesive matter, exhale it away again, and repeat the operation, till not the least scent of the spirit can be perceived in the remainder, which, when perfectly cold, dry, and kept for some days, will prove a transparent, brittle, or pulverable body, of a colour between brown and yellow, that will readily melt with heat, totally burn away in the fire, perfectly dissolve in oil, and alcohol, but remain untouched by water; which properties constitute it a rosin.

2. There are three ways in which rosins are prepared; viz. that of Nature of the nature, which converts the natural vegetable balsams into rosins, by productions. means of the sun's heat; that of our present process; and that other artificial way, whereby the like balsams are freed from their liquid parts with a gentle fire. All rosins appear much of the same colour, which is either a light or dark yellow; share the same properties, and differ from gums in nothing but this, that they will not dissolve in water; which property, therefore, sets the difference betwixt a gum and a rosin. Sulphur pass'd for a rosin with the ancients; and, indeed, it seems nearly allied thereto; bating for its want of transparency and indif-

disposition to open in alcohol of wine; tho' the addition of a little fix'd alkali will make it readily dissolve therein. The subjects of this process ought to be such as are dry; otherwise the alcohol employ'd to extract their rosin, will unite with their aqueous parts, and then barely act like unrectified spirit of wine.

*Their virtues
and uses.*

3. Almost all these rosins have a purgative virtue; tho' obtained from bodies that were not purgative themselves. Thus guaiacum-wood, for instance, even after it has been boiled and dried again, will give out a rosin to alcohol of wine; which, as I have found by experience, proves a very mild, and excellent cathartic; tho' the wood itself is constantly diaphoretic, and no ways purgative. And after the same manner rosins may be obtained from any kind of vegetable substances. When any of them are designed for internal use, as cathartics, 'tis proper to grind them with twice their own quantity of sugar, or to dissolve them in a little of the yolk of an egg, and wrap them up in something that may let them be conveniently swallowed, without sticking to the internal parts of the mouth, where they might prove troublesome; as being of their own nature viscid, inflammatory, and caustic or corroding. A small draught also of some proper spirituous liquor ought to be taken down immediately after them, in order to dissolve their texture, and make them mix with the juices in the stomach. These rosins are very strong hydrogogues; but no small danger and uncertainty attends their exhibition; as being apt to occasion hypercatharses, or purge the patient who takes them, even to death. For by reason of their tenacity, they sometimes run together, and stick fast to the intestines, which they vellicate, burn, and corrode in such a terrible manner, as to occasion a perpetual *diarrhæa*, with intolerable gripings. This is more frequently the case in persons of a dry habit of body, who have not moisture enough to dilute and wash these rosins away from the stomach, and the other parts they lodge upon, and carry them clear out of the intestinal tube. But in such bodies as abound with acids in the *prima via*, their force is thereby so weakened, as scarce to operate at all. 'Tis very remarkable, that any of the purging roots being infused in vinegar, or any acid spirit, lose their virtue. And thus when cream of tartar, or any other acid of the same nature, is mixed or taken along with jalap, scammony, or the like resinous cathartics, it greatly abates of their force. Our purgative rosins, also, are found inactive, or to have but very small effects, if the body abounds with aqueous humors, or hath only a small proportion of bile. In which case they ought always to be mixed with sugar, that they may the more readily unite with the water to be purged off: but when the bile is a predominating humor of the body, they are readily dissolved thereby, and so come to act with very great violence.

*The Doctrine
afforded by the
process.*

4. Hence we understand, that alcohol of wine dissolves the balsam, or harden'd oil of vegetables; which it lets go in water: and by these two operations, *viz.* solution and precipitation, we obtain their resinous, or unctuous

unctuous part; wherein their purgative virtue principally resides; and of which they being once deprived, will scarce afterwards operate as cathartics. Thus when the rosin has been extracted, by spirit of wine; from jalap, scammony, euphorbium, elaterium, colocynth, &c. what remains behind of them will hardly move the body, tho' they would purge violently before they are thus robb'd.

CHEMICAL HISTORY *of* ESSENTIAL EXTRACTS.

P R O C E S S LVI.

Exhibiting the manner of making ESSENTIAL EXTRACTS of the most costly aromatics, with pure alcohol prepared without alkalies; by an example in SAFFRON.

1. **M**AKE a tincture of saffron, with pure alcohol prepared per se, *The process.* in a tall glass, after the manner of the fifty-second process, and pour off the clear liquor by gentle inclination; put fresh alcohol to the remainder, digest again, and repeat the operation whilst the spirit will tinge itself thereon, or acquire any virtue from the saffron. (2.) Then mix the several parcels of tincture together; and with a gentle heat, scarce exceeding that of a healthy man, distil off so much of the spirit in a low, wide-mouth'd vessel, as to leave the tincture at the bottom of the consistence of oil, which will now become the essential extract of saffron*.

2. The most delicate, tender, odoriferous, and costly spices and perfumes, as *How practicable to advantage.* cinnamon, mace, nutmeg, cloves, ambergrease, musk, &c. may by this treatment be made into tinctures to advantage; the first part of the process, viz. the extraction of the tincture, being repeated till the bodies will communicate no manner of smell, taste, or colour, to the spirit; which will, therefore, remain possessed of their full virtues. For these ingredients are not endowed with a gross resinous sulphur; but one that is much more subtile, delicate and piercing; so as intimately to unite with pure alcohol.

3. These extracts are admirable in their virtue; which is extremely diffusive, *Virtues and uses of the productions thereof.* penetrating and corresponding to that of the subject; but here found in

* The spirit which ascends in the distillation, is the spirit of saffron; an excellent and very rich cordial.

a much higher degree; the form containing the presiding spirit and native balsam thereof. The extract of saffron, or opium, &c. as it were in an instant spreads its virtue through the whole body; or much more swiftly than the drugs themselves. And some experiments, made with this view in our university of *Leyden*, seem to confirm the truth of the assertion. For three grains of crude opium being here given to a man, the time it caused him to sleep was diligently observed; after which, the like quantity of the extract of opium being exhibited, the person was found by this to be thrown into a much deeper sleep, of longer continuance. And, indeed, two or three drops of the extract of opium, thus prepared, will procure rest, and ease the most grievous pain, in a surprizing manner. I have myself made an extract of saffron, one drop of which being mixed with a large proportion of wine, gave it an exceeding grateful scent, and taste, as well as a most beautiful colour; which shews the diffusiveness of its virtue. In effect, it is surprizing how great a cordial this extract is; and how greatly it exhilarates, tho' taken in a very small quantity. After the same manner, if *cantharides* be brought into an extract with alcohol, two or three drops of it, taken in wine that is free from acidity, will, in a few minutes time, give such a strangury, or difficulty of urine, and so great a convulsion of the bladder, as to cause an excretion of its mucus, and a bloody water.

4. If these extracts, by the continuance of heat, should be brought to a higher consistence, so as at length to become brittle, and capable of being reduced to a powder, they might then be mixed up with sugar, and thus possess all the virtues of their subjects in a portable form. I know a chemist who by this method of managing these extracts, made a great variety of medicines, greatly to his own profit and reputation. He took the extracts of spices, prepared in the manner of our present process, and with a gentle fire reduced them almost to a state of dryness; then, by adding a little dry sugar thereto, which drank up the remaining moisture, brought them into the form of a powder, to which, by means of a little cinnabar, he gave a beautiful colour; and thus composed very elegant powders, of uncommon virtues and efficacy. And of this kind is that powder which was first prepared at the court at *Zell* in *Germany*, and, upon account of its colour, called by the *Italians*, *Pulvis del oro*, tho' there is no gold at all in the composition.

Doctrine it affords.

5. Hence we see that the virtues of aromatics reside in that part of them which is dissolvable and preservable in alcohol; and which, when once separated from the drug, leaves nothing but a sceleron, or unactive matter behind it, destitute of the scent, taste, and virtues of the plant.

The cautions required in exhibiting the productions.

6. These extracts are not to be given without a deal of caution; and seldom in a dose greater than that of a few drops; which should rather be repeated the oftner, than to run the hazard of giving too much at once; otherwise, instead of strengthening and recruiting the patient, the

the texture of his blood will be entirely broke and dissolved thereby. They are given to the best advantage in a glass of some unctuous wine, such as *Spanish* or *Canary*. I am always cautious of giving more than half a grain of the extract of opium, for instance; yet dare, upon occasion, venture to order three grains of crude opium for a dose. So the extract of saffron, given too freely, might be of dangerous consequence; but will be of very great service in cases which require a sudden and extraordinary flush of spirits.

CHEMICAL HISTORY of QUINTESSENCES.

PROCESS LVII.

Exhibiting the manner of preparing QUINTESSENCES, with essential oils, and pure alcohol; by an EXAMPLE in the essential OIL OF FENNEL.

1. **U**PON a proper quantity of any essential oil, as that of fennel, for instance, pour twelve times as much, or more pure alcohol prepared per se; mix them together, and they will instantly unite into one similar liquor, which is the quintessence required. *The process.*

2. Care must be had in this operation, that not a drop of water remains either in the oil, the alcohol, or the vessel; for this would foul the liquor, and turn it milky. And if, after the mixture is perfectly made, water be poured to it, the whole will be disturbed, and become white; all the alcohol immediately joining itself to the water, and letting go the oil, which will now either float on the top, or sink to the bottom, according to its specific gravity. *The caution it requires.*

3. This method of dissolving oils in alcohol was utterly unknown to the ancients: and, indeed, a very celebrated chemist has lately denied the possibility thereof, without the assistance of alkalies. But our present process furnishes us with an undeniable example, that oils may be so perfectly dissolved in pure alcohol, prepared without alkalies, as totally to disappear therein, and compose one uniform liquor with the spirit. And for farther confirmation hereof, we may try it again with two or three drops of the essential oil of cinnamon, which is known to be so heavy, as to sink even in salt-water; yet even this ponderous oil being *Its certainty confirm'd.*

let fall into pure alcohol *per se*, will, as soon as ever it begins to descend therein, so perfectly mix itself with the spirit in its motion; as that every single drop of the whole shall contain some portion of the divided oil, as is manifest by the smell and taste of the cinnamon therein.

*Its excellence,
and uncommon
use.*

4. If the quintessences of this process be several times digested, cohobated and distill'd again, the oil therein will, at length, be broke so fine, as, like the alcohol itself, readily to mix with water. And this, perhaps, is as noble an experiment as any in chemistry; tho' at the same time we must own it is chargeable. Thus, if I would have an essence of cinnamon, that shou'd be potable in water, I take a dram, for instance, of the pure essential oil of that spice, and mix it with two ounces of pure alcohol *per se*; then, either by digesting them together, for a year, with a proper heat, or by repeated distillation, I bring the two to unite so permanently, and so intimately, as to mix with water, or the humors of the body; for, by this means, the repeated strokes of a gentle fire grinds and attenuates the parts of the oil to the size of those of the spirit, with which it therefore forms one homogeneous and unchangeable liquor, having the taste, scent, and virtues of cinnamon, as perfect as if the oil had been fermented with the alcohol; which, therefore, shews us another method of converting oils into spirits.

*The doctrine it
affords, with
the uses thereof.*

5. We are now given to understand the chemical effects of alcohol upon spirits, rosins and oils; and the affinity there is between it and oil, as it is a menstruum to all kinds thereof. Hence we likewise learn the manner of dissolving, diluting, and adulterating of oils; and at the same time adding to their taste, scent, and fineness. Hence also we are let into the nature of an oily spirit, and the methods of discovering any adulteration of that kind, by the admixture of water. Essential oils, we see, may easily be adulterated with alcohol; because they readily and intimately unite therewith: and at the same time that it dissolves them, it increases their virtues, and makes them stronger, more aromatic and subtile. But if there were any oil perfectly destitute of taste, scent and colour, it might be used to adulterate the richest essential oils, without a possibility of discovering the fraud. But there is no such known at present; or if some may, at first sight, appear to be of this kind, they soon turn rancid. And therefore, alcohol is the only thing that can be successfully employ'd in the adulteration of essential oils: and this cheat may be detected, as was said before, by the milky colour, and separation that will be procured when water is poured to such a mixture. For the like will not happen when the oil is pure and unmix'd.

*Medicinal vir-
tues of the pro-
ductions.*

6. These quintessences are of wonderful medicinal virtues, as is easy to imagine from their composition; being the mixture of an essential oil with a pure vegetable spirit: so that they may not improperly be called vegetable sulphurs, made potable, and raised to their utmost degree of power and efficacy. They are, doubtless, some of the most excellent and specific

Processes upon Vegetables.

[171]

specific medicines that can be obtain'd from vegetables; as retaining in an exalted degree of perfection, all the virtues of the plant whose oil they were made of. And farther than this, it is scarce possible to rise in the vegetable kingdom.

PROCESS LVIII.

Exhibiting the manner of preparing the QUINTESSENCES of ASIATIC Rosins; by an example in CAMPHIRE.

1. **R**educe that dry oil, the rosin of Asia, otherwise called camphire, to a powder, or considerably small parts, and pour thereon any quantity of pure alcohol, or spirit of wine; this will soon perfectly dissolve the camphire, like so much oil, whilst the whole appears one uniform liquor. (2.) But if water be now poured into the solution, the mixture will presently become turbid, white, and give out the camphire in its pristine form. And this wou'd be the consequence if the experiment were a hundred times repeated, or fresh solutions and precipitations made; without any alteration in the native form or virtue of the camphire.

2. Camphire being nothing but the essential oil of *carduus benedictus*, or the camphire-tree growing in Asia, it is plain from our present process, that what is a mere oil in the hottest regions, may appear like sulphur, as to dryness, in the colder; and therefore, that oils, as well as water, may pass into a kind of ice. As to the manner of the formation of camphire, we have frequent examples of it in the distillation of plants; the oil whereof sometimes adheres to, and blocks up the worm; but if it be clear'd out, and exposed to the cold air, it will there grow hard like ice, and turn to a kind of camphire; which, by distillation, wou'd appear under the form of a spirit. But the camphire of Asia is a rosin *sui generis*, and not like the concreted oils of other countries.

3. The quintessence of this process, prepared with camphire, is a very balsamic medicine, and powerfully resists putrefaction in the body. 'Tis also an excellent cosmetic, in case of an ulcerous skin; and admirably preserves from corruption such small animals as are suspended therein.

PROCESS LIX.

Exhibiting the manner of preparing dry QUINTESSENCES, from the liquid ones and the essential extracts of the fifty sixth PROCESS.

The process.

1. **T**O four ounces of loaf-sugar finely ground, and thoroughly dry'd, pour three drams of any liquid quintessence, composed of three parts oil, and one of alcohol; add one dram of the extract of the same kind of aromatic with that of the liquid quintessence, and in the manner of the fifty sixth process, and mix them well together, by grinding them in a dry glass mortar, without admitting the least moisture. Distil the mixture in a glass cucurbit, with a heat no greater than that of a man in health, till the alcohol of the liquid quintessence is come over; and what is then left behind will be a dry quintessence, which ought to be kept in well-closed vessels of glass.

Medicinal virtues, and uses of the productions.

2. The alcohol in the liquid quintessence is of use in this operation, by opening the body of the oil, and making it unite with the sugar. And after the same manner is the famous golden powder prepared, tho' sold at an exorbitant price, with the addition of a little cinnabar to heighten its colour. The form of these quintessences is beyond even that of the *elaosacchara*, and renders them principally serviceable to travellers and sailors; as being very convenient for carriage, and powerful in their operation; a very small quantity also serving for a dose. Thus, if a traveller shou'd in his voyage be at any time seized with a dysentery, for instance, a quantity of the dry quintessence of opium, no bigger than the head of a moderate pin, taken in a glass of wine, might readily and commodiously effect the cure, without other assistance. But for a warm, anodyne, portable cordial, of great efficacy in distempers proceeding from cold, and attended with weakness, take the essential oil of cinnamon, citron-peel, and orange-peel, of each one dram, of the oil of mace half a dram, that of cloves six drops, that of rhodium eight drops; and make all these into a liquid quintessence, or oily spirit, with a dram of pure alcohol *per se*; and thus there will be obtain'd as effectual and grateful a cordial, as any in the art of medicine. But to convert this into a dry, anodyne quintessence, take of choice opium, gently dry'd, one dram, and four drams of saffron; and with pure alcohol, prepared without alkalies, make an extract, in the manner described in the fifty sixth process; then draw off the moisture till there remains of the extract no more than about four drams, which are to be mix'd with the liquid quintessence just now set down, in the manner of the present process. This preparation being taken in the quantity of a single grain, up to ten, if there shall

shall be occasion, is such an immediate anodyne cordial, as nothing can exceed, being taken in a glass of *Spanish* wine. And after this manner the preparation may be varied at pleasure, within the limits of the proportions assign'd.

CHEMICAL HISTORY of Medicated Aromatic SPIRITS.

PROCESS LX.

Exhibiting the manner of preparing simple, medicated, aromatic spirits, from recent vegetables; by an example in ROSEMARY.

1. **T**O a proper quantity of the fresh gathered leaves of rosemary, pour eight or ten times as much spirit of wine, that has been once rectified *; and distil them either in a glass cucurbit, or copper alembic, so long as the spirit comes over, or any oily veins appear in the head, or upper part of the glass; and what thus runs off will be the simple, medicated, aromatic spirit of rosemary, otherwise called the *Queen of Hungary's water*; which being cohobated, or again distill'd from such leaves, or flowers of rosemary, will become the better and richer. The process.

2. This spirit is an improvement upon the simple waters of vegetables, tho' no more than a solution of the fine volatile, or essential oil of the plant in spirit of wine; and accordingly it turns milky, like the quintessences of the fifty seventh process, when water is mix'd therewith. Nature, and medicinal virtues of the production. In effect, this spirit scarce differs from that; being a mixture of spirit of wine with an essential oil, which may be readily separated by the addition of water; so that its general virtues and uses are already mention'd under that process. A like spirit may, by the same means, be obtain'd from other recent vegetables; so as to answer various intentions in the cure of diseases. Thus an hysterical, cephalic, or a stomachic, or a cardiac spirit, may be obtain'd from plants endow'd with such kind of virtues. Thus the simple spirit of the roots of garden-angelica, cohobated thrice, or till only two thirds of the original quantity of spirit of wine remains, is an admirable medicine in asthma's proceeding from a cold cause, or in a too great straitness of the chest;

* In order to make good hungary-water, the proportion of the spirit shou'd be less, in respect of the rosemary-flowers, that it may be fully saturated with the fine aromatic oil, and native spirit of the plant.

being

being taken in a proper quantity, early in the morning, and sweeten'd with a little sugar or honey. But the small and tender parts of the roots are best suited to answer this purpose, as having much more virtue than the grosser. And if the distillation be duly carried on, the spirit that comes over will be fully impregnated with the aromatic part of the subject, and entirely deprive what stays behind of all its spicy taste and scent; which again confirms, that the oils wherein these qualities reside, are drawn out by something similar to themselves. The simple spirit of rosemary is recommended as an excellent remedy in all diseases from a cold cause, especially in the vertigo, hysteric passion, apoplexy, &c. being taken in the quantity of a dram or two, along with a glass of *Spanish* wine. 'Tis also reputed an admirable cosmetic, by means whereof its inventor, the queen of *Hungary*, is fabled to have preserved herself as beautiful as *Helen* to an extreme old age. This is certain, that it greatly comforts the nervous system, when affected or disorder'd by cold; and sometimes does good in case of contusions and blackness of the flesh or skin.

PROCESS LXI.

Exhibiting the manner of preparing compound, medicated, aromatic Spirits.

The process.

1. **T**AKE of citron-peel, and China orange-peel, of each four ounces; lavender-flowers, red rose, and orange-flowers, of each two ounces; the roots of angelica, and Florence orrice, of each one ounce; dry'd mint a handful; cinnamon three ounces; cloves, nutmeg and mace, of each two drams; rectified spirit of wine four times the quantity of all the other ingredients; mix them together, and distil till the liquor begins to run white; and what comes off before that time will be a rich compound, medicated, aromatic spirit.

Farther continued, with the virtues and uses of the production.

2. If, after the spirit is all come over, pure water be pour'd upon the remainder, and the distillation be continued with a stronger fire, there will be obtain'd a rich kind of compound aromatic water, that may, in a less degree, answer the like intentions with the compound aromatic spirit. And the spirit itself may be render'd much more noble by two or three cohobations; especially if in the last distillation, a dram of saffron, or ground ambergrease tied in a linen-rag, be suspended by a string in the neck of the retort, or side of the head of the alembic, so that the vapor may freely pervade it on every side; for by this means the ambergrease will yield such an agreeable flavour both to the smell and taste, as not to prove offensive even to hypochondriacal or hysterical patients; so kindly is it dissolved by the surrounding dew or vapor, and so much better than in common digestion. And thus an uncommon medicine is obtainable, which might be called by the name of the invigorating

rating cordial. These spirits may be compounded and varied at every one's pleasure, so as to serve in hysseric, apoplectic, cephalic, or almost any other cases, according to the intention of a physician, who knows the specific virtues of the plant he wou'd employ. Thus a cephalic spirit, that shall powerfully raise the drooping patient, may be obtain'd by the distillation of *stachas* flowers, the *Syrian marum*, rosemary, lavender, rue, marjoram, sage, betony, master-wort, &c. in the manner of our present process. By a rectification of these compound aromatic spirits, a true essential oil or quintessence may be obtain'd; tho' it then becomes so subtil and volatile, as scarce to be contain'd in any vessel. For which reason we may usually content ourselves with the spirit that first runs off; as being procurable with less expense, and capable of keeping without loss, and answering the end of the physician.

3. We have already seen the effects of spirits upon oils, and what are the productions of the two by combination: the method at first laid down next requires us to shew, what will be the effects of fix'd salts, when united with oils. The principal oils in common use, are those obtain'd by expression, or those procured by distillation; and with both these the mixture of a fix'd alkaline salt will compose a soap. Express'd oils contain a large proportion of acid, which is separated from them by distillation; and therefore, express'd oils easier join themselves with fix'd salts than the essential, or such as are volatile; so that if any oil by expression, as that of olives, for instance, be mix'd with a fix'd alkali, a remarkable agreement may immediately be perceiv'd between them; for in the very instant that they mix they seem to form into a soap: and if they were, for a few hours, to be suspended at the moving sails of a wind-mill, so that they might be violently shook together, they wou'd mix and exhibit a saponaceous body; but at length, after the motion ceases, the saline and watery part will fall to the bottom, and the oil rise to the top. But boiling will permanently reduce them into one uniform body, called by the name of soap. By this means the salt will be so intimately united to the oil, as to become an essential salt, whose nature it is to be join'd with oil. But a light, distill'd volatile oil will not unite, by coction, into a soap with a fix'd salt; because being specifically lighter than water, it exhales in the operation. But in order to make soap with distill'd oils and fix'd alkali, we may use the strongest salt of quick-lime, join'd with pot-ashes, which being exceedingly attractive, has a strange propensity of joining all other bodies with itself, and particularly waters, spirits, acid liquors and oils. The method is to heat this salt, and, whilst it remains in that state, to pour the essential oil thereon; which is then strongly attracted into the salt with a hissing noise. Then the mixture being suffer'd to stand at rest for a few months, the salt and oil will in that time lose their respective natures, and turn to a very sharp soap, as we shall more fully explain hereafter.

CHEMICAL HISTORY of
S O A P S.

PROCESS LXII.

Exhibiting the manner of making SOAP, by boiling express'd oils with fix'd alkali.

The process. I. **T**O one part of good strong quick-lime, set in a glass vessel, add three parts of fix'd vegetable alkali, which is to be gradually moisten'd with water till the lime flakes, or falls asunder. (2.) Then boil this mix'd matter in a copper vessel, with a sufficient quantity of water, to make a lixivium, to be filter'd and exhaled, after the manner of our twelfth process, till it will support a new-laid egg; at which time it will be fit for our purpose, and is what the soap-boilers call their strongest mother or menstruum; and is indeed so strong, as, when it boils, immediately to consume almost any body that shall fall therein. (3.) This strong lixivium being let down with water, or, at first, exhaled only to such a size, as just to suffer a fresh egg to sink in it, is called by the same artists, their weaker mother, or common lixivium. (4.) With this weaker lixivium, thoroughly mix an equal quantity of any animal or vegetable oil, gain'd by expression, and boil them together over a soft fire, till at length, with continual stirring and mixing, they begin to unite into one uniform thickish mass; the superfluous water, but not the oil, being exhaled in the operation. (5.) Then add three parts of the strongest lixivium abovemention'd, in proportion to the quantity of oil, and continue them boiling, with a gentle heat, and perpetual agitation, till they become of that consistence, as when a little is drop'd upon a cold metalline plate, it appears in the form of an uniform consistent mass, or hard soap, capable of being cut with a knife.

Directions relating thereto.

2. If the soap shou'd happen to be too fat or greasy, so that the oil separates, or appears distinct, 'tis cured by adding more of the strong lixivium, and repeating, or continuing the boiling for a season. But if it proves too sharp, saline or corrosive, which may be known by the taste, and its relenting in the air, after it is cool'd, it requires the addition of more oil, and a farther degree of coction, till at length the due proportion of the ingredients is hit upon, so that neither may predominate, which always affords the most perfect kind of soap. And in this manner are made all the various soaps of Europe. But the Spanish and Venetian soaps are in greatest esteem, those parts abounding with the strongest

strongest fix'd alkali, and the best oil-olive; whereas in the northern regions, and particularly in *Holland*, we are obliged, for cheapness, to make use of train-oil, which gives our soap a black colour, and a disagreeable scent. The mixture of pure salt of tartar and oil, without the assistance of quick-lime, makes an admirable kind of soap.

3. By this process, fix'd alkali is made to unite with any kind of expressed oil into a similar mass that is soluble in water, oil, and alcohol, deterring, cleansing, purifying, attenuating, relaxing, opening, deobstruent, pectoral, resolving, edulcorating, sudorific, diuretic, vulnerary, anodyne; and in short, a kind of universal medicine, in such obstructions as are unattended with a putrefactive, or corrosive oil or alkali, that is, where no inflammatory disposition appears; being enabled, by the fineness of its parts, to pass thro' the whole system of vessels, and unite with all the fluids of the body. This extraordinary medicine may, upon occasion, be taken after the rate of an ounce in four and twenty hours; being divided into proper doses for that purpose, and so used at proper intervals. The most commodious form of exhibiting it seems to be that of pills; tho' it is also capable of mixing with a proper vehicle into any liquid form. But as of itself 'tis very apt to be nauseated by the patient, especially when it has long been used, it may be proper to tinge it red, and by that means disguise it, with a little gum-lac, cochineal, &c. or conceal it, by the admixture of any other ingredient, suitable to the intention of cure. Thus, for instance, in the hysteric disease, it may be mix'd to advantage with castor, oil of amber, or the like. 'Tis a medicine that I frequently make use of in my own practice; but then I always take care to prepare it with my own hands, because that which is commonly sold by the soap-boilers is never to be had without lime, which is very apt to corrode the stomach and intestines; from whence dangerous inflammations may arise. I am of opinion, that soap, rightly prepared, is one of the most pure and excellent medicines we possess; the numerous virtues whereof may ease the physician, who is acquainted with them, of a great load of simples of much less efficacy. We have already observed, that it is an almost universal deobstruent; or good for all obstructions arising from an excess in the diameter of the obstructing matter above that of the canal thro' which it ought to flow. If we consider what kind of matter it must be that causes obstructions in the body, we shall find that soap is admirably suited to dissolve its texture, and force it a passage with the circulating fluids. Now, it can only be the more gross and viscid parts of the fluids themselves, which, coming together fall into cohesion, and block up the cavity of the vessels: but all the animal fluids consist of nothing more than water, salt, oil and earth; of all which none is more apt to stick than the oil, upon account of the superior tenacity of its parts, and its indisposition to dissolve, like salt, in water. And in effect, we seldom find that earth is the cause of obstructions in the body; but an unctuous matter that sometimes ap-
[Z]
pears

Medicinal virtues, and uses of the productions.

pears like chalk, sometimes like rosin, and sometimes like an oily substance; all which are incapable of being dissolved by water, and hardly by common salt, but readily yield to fix'd alkali and alcohol; the former whereof, however, might first corrode the vessels of the body before it reached the part, whilst the latter wou'd coagulate the fluids contain'd therein, and by constringing the vessels increase the obstruction, at the time they produce the other effect: so that soap is the only remedy, which can be used with safety and success in the case of obstructions. And this will presently and effectually dissolve away inspissated and harden'd, or pitchy, unctuous matter, unite it to itself, and fit it for expulsion, or a free circulation in the canals again; and all this too in a manner as mild and gentle as it is effectual. Besides this, it surprisngly cures all internal wounds, foul ulcers, &c. but, as was hinted above, 'tis as bad as poison where the humors tend to a state of alkaline corruption; and therefore, it is highly mischievous in a phthisis, the stone, fevers, and principally in the plague. Thus it has been remark'd both by the *French, English, and Germans*, and particularly by *Sylvius, Forestus, and Diemerbroeck*, that in the time of the plague, almost all the soap-boilers, fullers, and such whose business led them to make use of soap, or even those who put on clean linen, that had been wash'd in soapy water, died of the distemper: whilst those were found to escape, who were in like manner any way concerned with acids.

PROCESS LXIII.

Exhibiting the manner of making SOAP, by digesting distill'd oils with fix'd alkali.

The process.

1. **P**UT of the strongest fix'd alkali, first thoroughly purged of its earth by solution, filtration and evaporation, into an earthen crucible, and suffer it to flow in a very strong fire, for two or three hours, or till it turns of a blue colour; and whilst it all remains in a fluid state, pour it immediately into an iron mortar made exceeding hot and dry. As soon as ever it ceases to flow, grind it well with a pestle of iron, till, upon cooling gradually, it be reduced to a very dry powder; which, whilst it is yet very hot, is to be poured into a low glass, made flat at the bottom, and wide at the mouth, that has first been thoroughly heated, and wiped perfectly dry: then immediately pour to the salt such a quantity of clear and well rectified oil of turpentine, or any other essential oil, as may rise about an inch above it; and if the operation be rightly perform'd, the fix'd alkali will now drink in the oil with a hissing noise. Then place the containing vessel in a cellar, that the matter may attract the moisture of the cool air, and in a few days time all the oil will be imbibed by the salt; after which, the matter is to be stirr'd about with a stick several times in a day;

Processes upon Vegetables.

[179]

day; continuing to pour fresh oil gradually upon it, till the salt be fully saturated; which it will be with about thrice its own quantity thereof. And thus in the space of three or four months, you will have the soap required, which, by way of eminence, is called the soap of philosophers.

2. Every circumstance mention'd in the process must be carefully observed, otherwise the experiment will not succeed: I myself was obliged to try it more than fifty times before I cou'd make it answer, tho' I exactly follow'd the directions of *Helmont*, *Starkey*, and *Matthew*. But the method here set down has never failed me once. The mortar and glass made use of must be exceeding dry; for the least moisture in any vessel employ'd in the operation wou'd cause all the salt to be thrown about the room with prodigious violence, break the vessels to pieces, and endanger the lives of the spectators: and, if the least drop of water shou'd be conceal'd in the oil of turpentine, or in the salt, no soap cou'd possibly be made thereof. For this reason, the salt, during the operation, must not be suffer'd to cool; because it wou'd then instantly attract the moisture of the air, and by that means prevent the uniting of the oil therewith. In this case, likewise, it wou'd stick so strongly to the sides of the mortar, as might cause great difficulty to separate it again. But the success of this operation depends chiefly upon the agitation of the mixture; by means whereof *Dr. Grew* tells us of a way to prepare this soap in four and twenty hours time.

3. This preparation goes under different names. It is called the soap of the adept, of *Helmont*, and of *Starkey*, and the corrector of *Matthew*; and is the thing of which they have all so largely treated. If any kind of poison be digested with thrice its own quantity of this soap, the whole becomes of an indifferent, or neutral nature; which is the reason, that in *England* it goes by the name of *Matthew's corrector*. This *Matthew* was an empiric, who made himself very famous by means hereof: for taking only the surface, or, as it were, the cream of this soap, and mixing it with opium, hellebore, or scammony, he procured a medicine of uncommon virtues; by which, *Starkey* also made himself eminent; the specific virtues of the opium and purging ingredients being supposed over-ruled or destroy'd in his pill, by the alkaline salt. There are some who add both the white and black hellebore, as also liquerise and saffron, as well as opium, in the preparation of these pills; supposing that by this means they become more antidotal: but this occasions them to prove somewhat emetic. And, indeed, the pills publicly sold at *Amsterdam* for *Starkey's*, being taken over night, will give a vomit the next morning.

4. Upon first digesting, and then committing this soap to distillation in a glass cucurbit, with a gentle fire, it affords a kind of unctuous, volatile salt, sticking to the sides of the glass; so that this process is accounted one of the methods of rendering salt of tartar volatile.

*Virtues and uses
of the produc-
tion.*

5. The medicinal virtues and uses of this soap are much the same with those of that in the foregoing process; tho' this is considerably less sharp, yet stronger, and of a much more heating and penetrating nature; on which account, it is excellent in all colical, hypochondriacal, and arthritical cases, where any obstructions are to be broke thorough. But, if taken in too large a dose, it stimulates so violently as to cause a distemper perfectly like the ancient *gonorrhœa*; and, therefore, ought to be used with caution. But when a great quantity of it is required, or a great obstruction to be removed, it ought to be well wash'd thro' the passages with large draughts of some emollient decoction; and thus it may be used with safety and success.

P R O C E S S LXIV.

*Exhibiting the manner of uniting the SOAPS of the preceding
PROCESSES with alcohol.*

The process.

1. **T**O a proper quantity of the soap either of the sixty second, or sixty third process, rightly prepared, and well dried, add a triple proportion of pure alcohol; digest them together, for a few days, and they will intimately unite, and compose the lesser elixir of philosophers; in which the three active vegetable principles, essential oil, essential spirit, or alcohol, and fix'd salt are united, without any mixture of the passive, or unactive principles, earth and water.

*Virtues and uses
of the produc-
tion.*

2. This is by the *Arabians*, *Jf. Hollandus*, *Lully*, *Ripley*, and others, called the lesser elixir of philosophers, to distinguish it from the grand one; for making the philosophers stone, which is prepared from metals. It is of this preparation that *Helmont* says, "If you cannot arrive at the stone of philosophers, search out for the lesser elixir; and become possessed of a medicine capable of curing all diseases." 'Tis indeed a wonderfully efficacious medicine in abundance of cases; but not universal. 'Tis a question, whether it can be with any safety administered in inflammatory diseases. Its virtue is exceeding penetrative, heating and detergent, as may be learnt by its taste; whereby 'tis fitted to pervade the whole body, and dissolve away whatever it finds therein of a glutinous nature. 'Tis much more powerful than soaps alone (especially when prepared by long digestion, which makes a more intimate union of the several ingredients;) as being a volatile, oily, spirituous, vegetable salt, or the joint union of the three active, or most powerful and exalted principles without allay. It is wonderfully heating and detergent; and a small quantity of it, being taken in the morning, with a glass of generous wine, will warm and invigorate the whole frame, and cleanse, and open

open all its canals. In general, it has the same medicinal virtues with the former soaps, only in a much higher degree; being, perhaps, the utmost that vegetables can possibly afford; or the art of chemistry procure from the vegetable kingdom.

3. Having now seen the effects of spirit of wine, alcohol, and oils upon vegetable salts; our next inquiry must be into the action of salts upon salts; which we shall exemplify in the different treatment of tartar.

CHEMICAL HISTORY of TARTAR.

PROCESS LXV.

*Exhibiting the method of preparing soluble, or tartariz'd
TARTAR, otherwise called the Samech of Paracelsus.*

1. **T**AKE a sufficient quantity of the whitest, purest, and most shining tartar, which is that in the largest lumps; reduce it to an impalpable powder, and boil it over a strong fire, in six or eight times its own quantity of clear rain-water, till it appears to be entirely dissolved; then, as the liquor continues boiling, with great care, and only drop by drop, at due intervals, let fall therein such a quantity of oil of tartar made per deliquium, as after having at each affusion excited a most violent ebullition and effervescence with very large bubbles, will at length put a stop to this phenomenon. When now, upon the affusion of a fresh drop of oil of tartar, the ebullition entirely ceases, run the liquor, whilst it is yet violently hot, thro' an hippocras bag; then exhale it to a pellicle, and afterwards suffer it to crystallize in the cold; by which means you will obtain a tartariz'd tartar, that will dissolve in water, or run even by the moisture of the air. Or, the solution itself, without being exhaled, may be kept under the same title for medicinal or chemical uses. *The process.*

2. 'Tis very remarkable, that the effervescence in this process wou'd not happen, if the alkaline liquor were poured upon crude tartar that was undissolved; the reason whereof seems to be this, that its acid salt in such a state is too intimately united with the other principles to admit thereof. Whence we may venture to draw this general conclusion, that those salts which, whilst they remain solid, or undissolved in the cold, will cause no ebullition with fix'd alkalies, may yet readily do it, and strongly, when applied together in a state of heat and fluidity. The oil of tartar here must be carefully drop'd in so long as it makes any ebullition; and the *Observations thereon, with the caution it requires.*

the affusion thereof shou'd immediately be stop'd, as soon as ever the liquor remains quiet, or free from that disturbance the drops of the liquid alkali before created; but if you cease the affusion before this point of time, the compound liquor will prove acid, on account of the predominancy of the crude tartar which is acid: and on the contrary, if more oil of tartar be added, after the ebullition ceases, the liquor will become of an alkaline nature, from the over-proportion of the fluid alkali.

*Nature of the
preparation
and process.*

3. This preparation goes pretty commonly by the name of the *Samech* of *Paracelsus*; but I greatly question, whether it be really that extraordinary medicine, by means whereof he declares he cou'd cure all kinds of wounds, without bringing them to suppuration; tho' it must be acknowledged, that *Helmont* wou'd have his tincture of salt of tartar pass for the *Samech* of *Paracelsus*. There is this extraordinary in the preparation hereof, that an uncommon transmutation is here made of the tartar, by its own fix'd salt; which alters its nature, and makes it neutral, or neither acid, nor alkali. Tartar is a body very hard of itself to dissolve, and opens not but to a large proportion of boiling water; for cold water will not dissolve it: 'tis likewise so solid and durable, as to remain, perhaps, for a hundred years, or more, undissolved in wine; and yet even this strong body, by the admixture of a little of its own alkaline salt, is in the present process render'd potable, and so soluble, as scarce to be kept from spontaneously relenting in a well clos'd glass; whence it has also obtain'd the name of soluble tartar.

*Medicinal vir-
tues, and che-
mical uses of
the production.*

4. By this mixture of the essential salt of a vegetable with its own fix'd alkali, an admirable new salt is produced, endow'd with laxative, purgative, attenuating, aperitive, sudorific, diuretic, and antihysterical virtues. It is an excellent purge in hypochondriacal cases, and does not leave the body bound up afterwards; for which reason 'tis likewise serviceable in costive habits, or such as go to stool but seldom. It also excellently attenuates, and cleanses away viscid phlegm; and might, perhaps, be made the basis of a medicine, to bring away sand, or the matter that forms the stone in the kidneys. 'Tis good in all splenetic, and melancholic disorders, and an extraordinary medicine in the jaundice, tho' grown inveterate; as likewise in all ulcerous cases, attended with foul or purulent matter; being, perhaps, one of the most efficacious salts afforded by chemistry. To answer these purposes, it may safely be given alone, being inoffensive to the taste, and neither alkaline nor acid, from the quantity of a dram to that of half an ounce, or more; or dissolved in any proper vehicle. Thus, in case of the gravel, for instance, it may be drank in the morning, with a large quantity of whey, or other diuretic liquor; and so of the rest. But if it be design'd as a cathartic, its dose may be gradually increased, from day to day, till it has its full effect. Besides its particular medicinal virtues, it is also an incomparable

men-

Processes upon Vegetables.

[183]

menstruum to dissolve vegetable substances, and especially such as are of a very tenacious or glutinous nature, or otherwise very hard to open: for by means of this preparation, they may be made readily and perfectly to join with an aqueous or spirituous liquor. Thus the tenacious body of myrrh, which is so difficult of solution, being once intimately penetrated with this salt, becomes almost totally soluble in spirit of wine, so as presently to afford a rich and noble tincture: which may seem a kind of mystery to some chemists, who know by experience that fix'd alkali, applied to this gum, binds up the surface thereof, and turns it as it were into a kind of crust, which prevents its yielding a laudable tincture. In short, it seems to be of a more penetrating nature, and dissolves much more readily and expeditiously than other essential salts, which usually require a considerable degree of heat, and a large proportion of water before they will unlock.

P R O C E S S LXVI.

Exhibiting the manner of preparing Regenerated TARTAR, or the Terra foliata Tartari of the philosophers, otherwise called the purging Salt of Sennertus.

1. **P**UT a proper portion of the strong fix'd alkali of tartar, first made The process. very dry by heat, into a large and clean glass vessel, and, by degrees, pour upon it any quantity of the strongest distill'd vinegar, at pleasure, suppose in all about seven or eight times its own weight, and by shaking the glass, or otherwise, mix them well together. This affusion being made at due intervals, a very small and short-lived ebullition will at first appear; but, as more vinegar comes to be poured on the salt, the ebullition will be the greater, last the longer, and still continue increasing both in magnitude and duration, as fresh vinegar is added, and the matter stirr'd about. Continue thus to pour in vinegar at the expiration of each ebullition, till the phenomenon can no longer be excited, even by motion, or shaking the glass, and by this means, after the whole has stood to settle, and deposited its feces, you will obtain a pure, transparent, scentless liquor, which is neither acid, nor alkaline, but of a sharp, piercing taste peculiar to itself. Filtre the liquor, or decant the clear part, and distill it in a retort almost to dryness; and in the operation the following phenomena will offer. (1.) A quantity of pure, and seemingly elementary water will come over, without either scent or taste. (2.) The body of the liquor, which was before transparent, or limpid, will begin to change its colour, and continue to do it every moment, so as at length to appear of a blackish brown. (3.) A gross, thick, unctuous liquor, in colour between black and red, and of a particular oily, alkaline taste, will remain behind at the bottom, of the retort. (4.) To this remainder of the first distillation, again pour, by degrees, a sufficient quantity

quantity of distill'd vinegar; and the phenomena of the ebullition will happen, as before, till the matter be saturated so as not to bubble, even when briskly stirr'd. Then again free the mixture from its feculent part, and commit the pure to distillation, as before: and again, insipid water will rise, and a thick, unctuous, dark-colour'd liquor be left behind. (5.) Continue, thus to repeat the process, till the spirit of vinegar comes over as strong as it was at first poured on; which will be an indication, that the salt is thoroughly saturated with acid; and, at length, dry the remainder over a gentle fire, to prevent the exhalation of the oil; and there will remain at the bottom a salt of a colour between black and red, of a most sharp and piercing nature, very particular in its taste, saponaceous, or of an aperitive, medicinal virtue, and almost totally volatile with a considerable degree of heat; but, if urged with a strong fire, the major part of it turns to a true inflammable red oil; and when dried in a glass vessel with a more moderate heat, and suffer'd to cool, it runs together like a mass of melted silver, and, like talc, becomes separable into thin plates, that are again fusible by fire. Whence we see the reason why the ancients called it *Terra foliata Tartari*.

The cautions it requires.

2. The circumstances described in this process are to be carefully observed, in order to render it successful. Particularly, the fire employ'd in the exhalation must be very soft and gentle; otherwise the oil might easily be evaporated, or the whole quantity of salt driven away. The fæces deposited by the mixture of the salt and vinegar, are here to be laid aside, as useless or detrimental in the operation. These fæces will be found at the bottom of the containing vessel, tho' the tartar employ'd were ever so pure; but from whence they shou'd proceed is very hard to say. As soon as ever the liquor to be distill'd comes to be heated, a great ebullition will arise; which, however, is not to be ascribed to the action of the fire, but to the salt; and after this, the liquor passes successively thro' all the degrees of colour, from limpid to dark-brown, or a kind of black. The name of philosophical earth seems given to the last production of our process, on account of its being taken for a kind of nutritive matter, useful in the preparation of the philosophers stone, which is supposed to grow from hence, as a plant does out of the ground. It likewise goes by the name of the purging salt, or tartar of *Sennertus*, because it was by him esteem'd a very uncommon and extraordinary medicine to cleanse the body.

Its chemical uses.

3. The process itself supplies us with a general method of regenerating salts from alkali and acid; for it succeeds as well in the fossil, as the vegetable kingdom; with this only difference, that the salts thus made from minerals become more fixed than those from vegetables. It is a very fruitful experiment, and furnishes several observations, which appear as so many chemical paradoxes. For, (1.) the ebullition, or, as it may improperly be called, the effervescence here made, instead of heating, really

really increases the coldness of the liquor; and that in proportion to the quantity of motion excited; so that the most violent ebullition shall cause the most intense degree of cold; as is manifest by the thermometer; whilst yet it is generally allowed, that attrition is productive of heat; which in effect is the case in other kinds of effervescence. (2.) The second affusion of the vinegar upon the salt excites a greater ebullition than the first, the third a greater than the second, and so up to the fifth or sixth, or till the point of saturation be gained; which is directly contrary to what happens in the mixture of other salts of an opposite nature; for we commonly find that these operate the more violently upon one another, or cause the greater effervescence, the stronger they are respectively; but in the present case, the weaker the fix'd alkali is made by mixing with the acid liquor, the greater ebullition is excited, till at length the salt has imbibed its fill; which *M. Homberg* remarks for a wonderful phenomenon, as being contrary to the general opinion of chemists, who have given it as a rule, that the stronger the fixed alkali is, the greater will be the ebullition; whereas we learn from our experiment, that an alkali may be too strong to give the appearance of an effervescence with an acid. (3.) The mixture by distillation affords a large proportion of pure water; all that is acid in the composition remaining at the same time fix'd in the alkaline salt: so that what we call by the name of acid spirits have an improper appellation, being in reality no more than acid salts dissolved in water, and that in a very small proportion. It is probable, that all the acid or saline matter which composes vinegar, amounts not to more than a two hundredth part of the whole; as appears by the quantity of water which may be drawn from it by repeated distillation. (4.) Lastly, a large part of *terra foliata* may by heat be reduced to an inflammable oil; as I found to my cost, upon trying to sublime half a pound thereof; and this seems as great a paradox as any of the former. For, how is it possible, one might say, that a fix'd salt, which for the space of many hours has been exposed to a most violent fire, that must needs consume its unctuous part, if it had any, and render it exceedingly dry and lean; and the spirit of vinegar, a liquor allow'd to be the least unctuous of all that are in nature, shou'd, by their mixture, and the treatment of our present process, afford so large a quantity of oil? To this it may be answer'd, that the oil thus obtain'd was latent in the acid salt of the vinegar; or else we must say, that it was produced *de novo*, from a body in which it did not before reside; or lastly, which is somewhat hard to suppose, that it was latent in the fix'd alkali. And that oil may, in a wonderful manner, be concealed in liquors, so as not to be discover'd but by some such method as this, appears probable from hence, that having let some pure spirit of boxwood, in which no oil at all appear'd, stand for the space of two years, it at length deposited a large quantity thereof. And that vinegar itself contains a proportion of oil, appears from its colour, which, tho' diluted

by the large proportion of water wherein the acid salt is dissolved, will be made more manifest, by exhaling its aqueous part, upon which the remaining liquor will become of a full red; and therefore, it must necessarily participate of oil, because it is to this that all the colours of bodies are owing; for, neither pure salt, pure water, nor pure earth have any colour at all. Hence we may observe, that spirit of vinegar is not a simple, but a particular oily acid, unlike to spirit of nitre, spirit of sea-salt, spirit of vitriol, &c. all which will afford no oil, when mix'd with the fix'd alkali of tartar. And thus likewise *Saccharum Saturni*, which is prepared from vinegar and lead, appears to contain a large quantity of this kind of oil. For, scarce any body will pretend, that lead contains a sulphur soluble by vinegar, which being thus converted into oil, may come over in that form upon distilling the *Saccharum Saturni*. We therefore, venture to assert, that there may be latent oils in acid bodies.

Its physical and medicinal uses, with the virtues of the productions.

4. The chemical and philosophical uses of this experiment are very considerable. It lets us into the method of rendering salt of tartar volatile; of preparing an admirable menstruum for vegetable substances scarce otherwise dissolvable; the opinion of the ancient chemists as to *acetum radicum*; the manner of converting the spirit of vinegar into oil; the nature, production, and change of colours, tastes and odours; fluidity, fixedness, volatility, and cold effervescence; and lastly, it supplies us with a method of obtaining a compound saponaceous salt, that is neither acid nor alkaline. A volatile salt of tartar has by many been treated as a chemical non-entity; but by our present experiment it appears to be no fiction. Thus I remember I once lost a whole pound of salt of tartar, which had been thoroughly drench'd with vinegar; whilst, with some other view, it was too long detain'd in the fire. By means of our preparation, we can readily make a menstruum capable of dissolving even myrrh, gum-lac, gum-hedera, or the like glutinous vegetable substances, with a gentle heat, which is otherwise exceeding difficult to effect. The ancients, and particularly the *Arabians*, have wrote a great deal about the *acetum radicum*. Many are of opinion, that is no more than vinegar several times drawn over from salt of tartar; and at length united with it. But *Zwelfer* is merry with this conceit; being positive, that the virtues of both are destroy'd by the operation. There is indeed some truth in the assertion; but *Zwelfer* concludes too hastily; for the ancients never pretended, that the vinegar was made sharper by this means; but only, that it was by this union fix'd in its own root, from whence it had its rise; on which account they gave it the name of radicated vinegar, and supposed it to be, tho' not more acid or alkaline, yet a much more noble menstruum, or medicine, than either vinegar or tartar alone. And indeed, its medicinal virtues are exceeding great; for, by its saponaceous quality, it opens all the obstructions of the *viscera*, more effectually than any other medicine hitherto discover'd: and schirrous cases themselves give way

to it. I have myself seen surprizing things perform'd by its means, particularly in scirrhoties, and even in that of the liver, which it gradually dissolves, and wears away with great ease and safety; as acting without acrimony. 'Tis also excellent in disorders of the eyes; being fitted to take off films or specks therein, cleanse the parts, and cure such cataracts as are not grown inveterate. And from this foundation *Minderrus* has a collyrium, prepared with sal-ammoniac and distill'd vinegar, which *Zwelfer* has spoiled, by attempting to correct and improve it. Thus I remember, a chemist was once surprized at my prescribing a mixture of salt of tartar and spirit of vinegar, as if they had been destructive of each other; whilst my intention was to order something that shou'd have a saponaceous and resolving virtue. The changes of colour, observable in the distillation of the liquor, were, doubtless, caused so gradually by the increase of the proportion of the latent oil in the mixture, with respect to the remaining quantity of water; which every moment gave the oil a greater opportunity to manifest itself, upon which all colours depend. Our experiment likewise furnishes us with a remarkable instance, how far fluidity, fixedness, and volatility depend upon mixture, or a mechanical alteration in the parts of the bodies concern'd. Fix'd alkaline and saline bodies require a strong heat to make them flow; but our preparation, consisting of them and vinegar, runs like wax, almost as soon as ever it feels the fire. This great disposition of our preparation to flow with heat, and the resemblance it bears to talc, gave occasion to *Tachenius* to pretend he cou'd dissolve that hard intractable body; and by this artifice he imposed upon several, till at length the cheat was discover'd by the prince of *Holsace*. On the other hand, the acid of the vinegar, which was volatile before, is by the operation so fix'd in the tartar, that nothing but pure water comes over in the distillation; yet when the remaining matter comes to be filtred, crySTALLIZ'd, and dissolv'd again, in order to make a pure white talc, 'twill almost totally evaporate, tho' it before endured a stronger fire. Thus, whilst I once, by this means, endeavour'd to give a whiteness to this salt, I lost almost the whole quantity in the second operation. The observation of the thing was first made by *Baubin*; and I here think proper to repeat it, because *Sennertus* inadvertently directs us to depurate the salt, I know not how many times, after this method, in order to make it white.

PROCESS LXVII.

Exhibiting the manner of dissolving Tartariz'd Tartar, or making a Tincture thereof, in alcohol, by digestion.

The process.

1. **T**O a sufficient quantity of the crystals of tartarized tartar, gently dried, reduced to fine powder, and put into a tall glass, pour so much pure alcohol, prepared with fix'd alkali, as will swim the breadth of two fingers above it, and digest them together with a heat sufficient to make them simmer; by which means, a solution will be made, and a fat, spicy-flavour'd, gold-colour'd tincture obtain'd; which being poured off, and a fresh parcel of alcohol added to the remains, and the operation repeated, there will, at length, be left nothing but a perfectly white crystalline salt, adhering to the sides of the vessel.

Its chemical uses.

2. This process shews us a method of purifying and whitening salts, and freeing them from their oil; namely, by extracting their tinging or unctuous parts with alcohol. And as in digestion, the soluble tartar here unites with the spirit into a softish kind of substance like wax; those are mistaken who assert, that salt of tartar cannot be brought into such a form with alcohol.

Medicinal virtues of the production.

3. This tincture is of a saponaceous, aperitive, and aromatic heating nature; and principally recommended for the cure of fresh wounds; they being touched therewith once in the space of twenty-four hours: when so used, 'tis said by the elder *Helmont* to prevent their suppuration, and heal them without a scar.

PROCESS LXVIII.

Exhibiting the manner of dissolving Regenerated TARTAR, or making a tincture thereof, in alcohol.

1. **T**O a proper quantity of regenerated tartar, carefully dry'd before a ^{The process.} gentle fire, pour as much pure alcohol as will cover it to the breadth of two or three fingers; then digest them together with a soft heat, and by that means there will be made a tincture, or almost total solution of the salt, in the form of a red, unctuous, saponaceous, acid and spirituous liquor; only a very small quantity of faces remaining at the bottom.

2. This process gives us another method of intimately uniting volatile, fermented, acid salts, with the fix'd alkaline ones, by the interposition ^{Its chemical use.} of a pure vegetable sulphur, so as to form a compound, volatile, oily, and saline spirit; which also, as well as the production of the sixty fourth process, is therefore call'd the *lesser medicated elixir of philosophers*; the difference only consisting in here substituting acid for oil.

3. The tincture of regenerated tartar is a noble medicine in case of ^{Its medicinal use.} obstructions; and may at all times be exhibited with the utmost safety, unless the disorder be attended with an inflammation, or the constitution be naturally hot. It powerfully resolves all scirrhus and strumous swellings, or indurations of the glands; and may be of service in the gout and dropsy, provided the *viscera* are not corrupted. It is of an exceeding penetrative, yet inoffensive nature; acting with the greatest gentleness and ease, either as a sudorific, diuretic or cathartic; as it shall be determin'd by the virtue of the vehicle, or medicine, along with which it is given. It may be taken in the quantity of a dram for a dose, in the same manner as was formerly mention'd of the salt of *Tachenius*. The only inconvenience that attends it is its costliness; which renders it less generally useful. Instead of it may be employ'd, for those of narrow circumstances, the filtered solution of potashes, made by heat, with twenty times its own quantity of vinegar; which is an admirable medicine, being used, by way of fomentation, in scrophulous and scirrhus tumors. But care must be had in the preparation fully to saturate the salt with acid, otherwise it will excoriate the part to which it comes to be applied.

PROCESS LXIX.

Exhibiting the manner of preparing Harvey's Tincture of Salt of TARTAR, with rectify'd spirit of wine.

The process.

1. **U**PON a proper portion of salt of tartar, calcined to a perfect fix'd alkali, and reduc'd, whilst thorowly dry, to a powder, and put into a tall glass, pour twelve times its quantity of spirit of wine, that has been only once rectify'd; and boil them together, with a gentle heat, for the space of thirty six hours: by this means there will be obtain'd a deep red, or black colour'd tincture, of a penetrating, alkaline, and lixivious nature; which, by a gentle inclination of the vessel, is, when cold, to be poured off, or otherwise separated, as by the filtre, from the imperfectly dissolv'd salt, that, in a fluid form, will remain behind.

By whom invented.

2. My method of preparing this tincture, is in a very tall glass, with the heat of my wooden digesting-furnace; which does not exceed that of the body of a man in health. It is call'd by the name of *Harvey*, only because that learned physician of *London* heartily recommended and successfully prescrib'd it; being originally the invention of *Paracelsus*, and one of his principal secrets.

Its medicinal uses.

3. This tincture is accounted a noble detergent medicine; the spirit of wine actually dissolving a considerable part of the fix'd alkali. It is useful chiefly in such habits as abound with acid humors and viscid phlegm; or in those cases where obstructions in the viscera are to be remov'd, or the thick offending juices to be forc'd thro' the kidneys, or thrown off in sweat, or insensible perspiration. Thus it is successfully used by hypochondriacal, leucophlegmatic and dropsical persons; in the green-sickness, scirrhus tumors, the scurvy, and all those distempers which proceed from a cold, acid, phlegmy or depauperated blood, that blocks up the canals. For the same reason it admirably deterges old ulcers, whether external or internal, even those of the lungs; provokes the appetite, strengthens the stomach and intestines, helps to discharge their faces; and in short, it may be made serviceable in every case that is not attended with an inflammatory disposition; being determin'd and fitted for the purpose by the particular vehicle, or other ingredients, with which it is given. It may be taken in the quantity of two or three drams for a dose, twice or thrice a day. *Dr. Harvey* orders a spoonful of it at a time, in the dropsy, scurvy, and phthisic, if the patient be weak, and the juices acid, mix'd along with some soft sort of wine, hydromel, or mead; and the dose to be repeated three or four times in a day: by which means he recover'd abundance of hydropical patients; the medicine bringing away an incredible quantity of urine. It might likewise be mix'd, for taking, with honey, or any opening syrup, not

so acid as to cause an ebullition therewith, as the syrup of the five opening roots, or the like; which is a convenient manner of exhibiting it in drop-sical cases. And when thus repeated in small doses, as that of a dram or two, several times a day, it wonderfully improves a vapid blood, dissolves away the mucus that obstructs the vessels, and gives warmth and vigor to the whole body.

PROCESS LXX.

Exhibiting the manner of preparing Helmont's Tincture of Salt of TARTAR, with alcohol.

1. **T**AKE any quantity of white, crude tartar, in the lump, wrap it up The process. in thick cap-paper, first made a little moist, and lay the whole upon an iron-plate, plac'd upon a stratum of live coals; then build up a clear fire all around the plate, and gradually heighten it to the strongest degree; by which means the kindled matter will at length be made to flow, and unite into one white, spongy mass; which being detain'd, for the space of half an hour, in the same degree of heat, is call'd by the name of calcin'd tartar. (2.) When the coals below the plate are consum'd to ashes, take away the surrounding fire, and, with a pair of tongs, remove the calcin'd tartar, or hard saline mass, which will be now reduc'd to little more than a fourth of its original weight, and dissolve it in hot water; filtre the solution, and exhale it in an iron-vessel, over a strong fire, towards the end of the operation; keeping it continually stirring with an iron spatula, or ladle, till there remains nothing behind but a very dry and snow-white salt, call'd by Helmont the principal of fix'd alkalies, but vulgarly the common salt of tartar depurated*. (3.) With this salt of tartar fill a close, strong crucible, and, with the gradual heat of a wind-furnace, keep it continually flowing for the space of six or eight hours, or till it becomes of a brown colour; then presently pour it out into a metalline mortar, that has first been made exceeding hot and dry; and thus, with a heated metalline pestle, reduce it into as fine a powder as is possible. (4.) Put this powder, whilst it is yet very dry and hot, into a tall, well heated and well dry'd glass, with a slender neck, and pour upon it pure heated alcohol enough to float five or six fingers breadth above it; the alcohol, upon this, will be drank in by the salt, with such a kind of noise as that made by the slaking of lime with water. Then boil them together over a soft fire, for the space of thirty-six hours, and by this means a deep red tincture will be extracted from the fix'd salt, of a perfect balsamic taste; which, when cold, is Helmont's Tincture of salt of Tartar.

* This is the common salt of tartar of the shops.

Cautions to be
observed in it.

2. There are many eminent chemists, and among the rest the famous *de Maats, le Mort*, &c. who deny the possibility of extracting a tincture from salt of tartar, with pure alcohol; but they are certainly mistaken, and fail'd in the experiment only for want of attending to all the circumstances of it, without which it will never succeed. Thus if the salt be not exquisitely dry, or the least aqueous mixture be left in any of the vessels, or the alcohol made use of, the spirit will thereby be kept from acting upon the salt, and so no tincture will be produc'd. Thus it is found impossible permanently to mix pure alcohol with oil of tartar; the water acquired by the salt in running *per deliquium*, preventing the entrance of the alcohol into it. The same will likewise happen if the fix'd alkali remains so long in the mortar as to attract the moisture of the air; which it does so strongly as scarce to be kept a few minutes cold without relenting. 'Tis observable in calcining the tartar, that its spirit goes off into the air, together with its oily acid of the first order; whilst a considerable part of that of the second order remains with the other spirit in the mass, so as to give a high colour to the limpid alcohol. The tartar may likewise be calcin'd in an open fire, without the assistance of a metalline plate, by throwing it upon live coals, and covering it over with others; but then it will melt and run among the ashes: from which, however, it may again be freed by means of a sieve. The lixivium, in the second step of the process, is to be kept stirring towards the end of the exhalation, in order to prevent the salt from sticking to the bottom of the vessel, and preserve its whiteness. In the third step of our process, the salt in the cover'd crucible ought to be detain'd for a considerable time in the fire, to fit it for the purpose; and indeed the longer it is here kept close, the better it will be. During its detention, it will pass thro' several degrees of colour, provided no smoke or other foreign body comes at it, till at length it arrives either at a greenish blue, or a brown. The degrees of fire ought here to be carefully regulated at first, in order to prevent the cracking of the crucible, and to keep the salt in a proper fluor, till it be reduc'd to the due colour; which may be known by dipping the end of a dry iron rod into the crucible, as it stands upon a tile in the fire, and bringing away what salt shall stick thereto. Thro' the whole operation, great care must be had that not the least drop of water touch the melted salt; for this might make the crucible, glass, or mortar, fly into a thousand pieces, and throw the salt about the room in a desperate manner. Instead of pouring the heated alcohol upon the salt of tartar, it may, perhaps, be more commodious to throw the heated salt into the hot alcohol, contain'd in a proper vessel of glass set ready at hand for the purpose.

Its chemical
uses.

3. This tincture, we see, is a most subtil oil, or sulphur, united, by means of fire, to the most subtil part of a fix'd alkali; whence it is in reality a very subtil and attenuated kind of soap. That it is an actual tincture of the salt, appears from the colour which the alcohol acquires upon

upon it; tho *de Maats* will needs have this to be no proof; pretending that the spirit it self would by digestion at length become of this colour, without the assistance of the salt. But experience shews, that pure alcohol will remain for a series of years without at all changing its colour by being digested *per se*. Besides, as the taste and smell of the tincture confirm it gain'd from the salt of tartar; so likewise does the touch; for it is saponaceous, and detergent to the hands. And further, by distillation it actually leaves a quantity of fix'd salt of tartar behind it; and even what comes over will exercise hostility, or make an ebullition, with acids. So likewise, if the tincture be suffer'd to rest for some years, it will deposite a true oily salt of tartar. All which are arguments beyond exception, that this preparation is an actual tincture of a fix'd alkali. Whence we are furnish'd with an example, that the strongest and most fix'd alkali may be united with alcohol, and by that means render'd volatile: a secret of which *Paracelsus* and *Helmont* have so largely discoursed. And thus the remaining part of the salt, left undissolv'd by the spirit, after a long digestion, and the extraction of the tincture, loses a great deal of its alkaline acrimony; and, contrary to the nature of salt of tartar, will flow by a gentle fire, like wax, so that at length it becomes an incomparable soap; for no alkali is more subtile than that of tartar, nor oil more pure and fine than that of alcohol. This was originally the observation of *Mr. Boyle*, who gives a great commendation of the salt by such means procur'd; tho other chemists have commonly thrown it away as useles. And the longer the spirit is digested upon it, the more saponaceous it becomes; till at length, it will not make an ebullition with acids.

4. This tincture is an admirable attenuating, aperitive, alkaline, saponaceous, and oily medicine, as well as menstruum, of the same virtues with that of the preceding process, tho not capable of being, like that, exhibited alone, for fear of excoriating the part along which it passes. For this reason it ought, when taken, to be diluted with water, which renders it much the same thing as *Harvey's* tincture of salt of tartar; which in this case might commodiously be substituted for it. As a menstruum 'tis wonderfully serviceable in extracting the tinctures of stubborn, gummy, or sulphureous, vegetable bodies, such as myrrh, gum-lac, amber, &c. which, with the help of digestion, are excellently dissolv'd thereby. But being so laborious and chargeable to procure, *Harvey's* tincture is generally allow'd the preference for medicinal uses.

5. We have now seen the fix'd alkali of vegetables united with water, two kinds of oil, express'd and distill'd, with vinegar, common spirit of wine, and pure alcohol; whence we may perceive that it is convertible into almost any form, at pleasure. And this brings us to the preparation of elixirs, as the next link of our chain; they being no more than strong tinctures, in which the ingredients employ'd are almost totally dissolv'd. And these we shall shew how to make, with the various productions of our former processes; as particularly with spirit of vinegar, fix'd

The medicinal and chemical uses of the production.

Introduction to the History of ELIXIRS.

fix'd alkali and distill'd waters, alcohol and fix'd alkali, cartariz'd tartar and spirit of wine, regenerated tartar, &c.

CHEMICAL HISTORY of ELIXIRS.

PROCESS LXXI.

Exhibiting the manner of preparing ELIXIRS with distill'd vinegar, by an example in Elixir Proprietatis.

The process.

1. **T**O an equal proportion of myrrh and aloes, reduc'd to fine powder, and half the quantity of either of fine saffron, pour twelve times their own weight of good spirit of vinegar, and let them simmer gently together in a tall glass, for the space of twenty-four hours; then, when the whole is cold, pour off the clear tincture, or let it stand upon the undissolv'd part of the ingredients, in a close vessel, under the name of elixir proprietatis.

Cautions to be observed in it.

2. Only half the quantity of saffron, in proportion to the two other ingredients, is here order'd, that the medicine may come the cheaper; and indeed the rest may well enough be spared, if all the ingredients are at the same time committed to the menstruum; which being, by means of the operation, sufficiently saturated with the myrrh and aloes, cannot take out the virtue of so large a proportion of saffron. And for this reason, when the medicine is design'd rather as a cordial than a balsamic laxative, the saffron is first put to infuse, in an equal quantity with the other ingredients, for some time before the latter are added. Instead of making the ingredients boil in the menstruum, it might suffice to keep them longer together, as for the space of several days, in a moderate heat of digestion: and they may, when cold, be likewise suffer'd to stand together; because by this means the menstruum will be the more impregnated with the soluble parts of the ingredients.

Its origin, and history.

3. *Paracelsus* was the man who first reduced these three ingredients into the form of a liquor; to which he gave the name of *elixir proprietatis*. The word *elixir* is of *Arabic* derivation, and originally signifies a great assistant; to which in the present case he added the word *proprietatis*, as believing, according to what he tells us in his book upon long life, that this medicine was peculiarly adapted to preserve the native balsam of the human body, and prolong its duration beyond the age of *Methusalem*: but no body before *Helmont* pretended to say wherein its peculiar virtue or power of doing this consisted. *Helmont* tells us, that three things are requir'd in order to the attainment of long life, viz. cleans-

ing

ing the body of what is feculent in it, preserving it from putrefaction, and raising the spirits thereof; all which he says are effected by the ingredients of this elixir; the aloes purging off whatever might obstruct the vital functions, the myrrh defending the body from corruption, and the saffron powerfully raising the spirits, and enlivening the heart. The Greek writers observe, that the *Egyptians* were possess'd of some certain secret way of embalming, or preserving dead bodies from corruption, even for a thousand years; and this, according to *Herodotus* and *Diodorus Siculus*, they effected by means of aloes, myrrh, and saffron. *Paracelsus* having learnt so much, presently concluded, that men might be made immortal, if a way could be discover'd of preserving the humors of their bodies from putrefaction; not considering that distempers may prove mortal, tho they give no signs of putrefaction in the body: and this notion prevail'd so strongly with him, that he for ever after imagin'd the preservation of health and continuance of life might be obtain'd by taking medicines that oppos'd corruption in the body. *Helmont* likewise gave a little into the same opinion. And no wonder if two such great men should be mistaken in this affair; considering they were unacquainted with the circulation of the animal fluids. The authority of these famous chemists brought a great many more into the same sentiment; so that at length there were some who pretended, that as the grand elixir is the remedy for all impure metals, gold alone excepted, as being of it self sufficiently pure; so the *elixir proprietatis* of *Paracelsus*, or myrrh, aloes and saffron brought into one homogeneous liquor, was the cure of all diseases, and particularly adapted to the preservation of life. We must indeed allow, that scarce any known medicine is more friendly to the human body than this elixir; and *Paracelsus* tells us, he was induced by *Christian* charity to publish the secret of its preparation for the benefit of mankind. He took equal quantities of these ingredients, and digested them together in cinnamon water, or spirit of wine impregnated with the essential oil of cinnamon, for the space of three months, in a glass hermetically seal'd, before he pour'd off the clear liquor from the remaining fæces. But *Rufus Ephesus* was the first who employ'd a mixture of the same ingredients, in the form of pills, as an antidote against the plague; which he did with such success as increas'd *Paracelsus's* opinion of their virtues. And to say the truth, these purging pills of *Rufus* are excellent in all distempers which proceed from a cold cause, or require the heat of the body to be augmented in order to their cure; but they have this fault belonging to them, that they render such as take them subject to the piles, on account of the tenacity of the aloes they contain; which faculty therefore requires to be corrected by some proper dissolvent; as was afterwards done by *Paracelsus*. But *Crollius*, in his *Basilica Chemia*, denies that this elixir can be prepared in *Paracelsus's* manner; and with some justice on his side: but himself is likewise mistaken in expecting to amend the thing by digesting the ingredients with oil of sulphur *per campanam*;

campanam; tho he first moistens them with spirit of wine: for as soon as ever that sharp liquor is pour'd upon the ingredients, the myrrh and aloes are thereby burnt to a kind of coal; so that the addition of fresh spirit of wine cannot afterwards extract a twentieth part of their virtue, and only a small portion of their rosin; leaving the other parts untouch'd, in the form of a crusty matter at the bottom of the glass. *Helmont*, therefore, advises to digest them without any menstruum at all, till they are brought into a kind of oil; and afterwards to pour the spirit of cinnamon thereon: but neither will this method answer the end proposed; for thus also the ingredients will be burnt. My opinion is, that if we would make an universal medicine of this elixir, we must vary the menstruum according to the intention of the physician; and thus, in cases where a peccant alkali predominates, I know no better liquor to prepare this elixir with than the spirit of vinegar; which is an unctuous acid, that agrees very well with the human body, and dissolves all the ingredients as perfectly as any other menstruum: for which reason this preparation of the elixir may commodiously be used instead of that made with oil of sulphur *per campanam*.

Medicinal virtues of the production.

4. This elixir is a medicine of great virtues, and capable of entering all the vessels of the body; but as prepared with vinegar, 'tis thereby principally determin'd to such distempers as proceed from an alkaline cause, tending to introduce a corruption of the humors; or where the body abounds with a viscous, thick, corrupting bile, or viscid phlegm. It also discharges the intestines of their load, gives an appetite, and admirably provokes both sweat and urine. In the alkaline species of the scurvy, to which such as use the sea are particularly subject, 'tis preferable to any medicine I know; as admirably preserving or repairing the corrupted gums, and other scorbutic disorders of the mouth, if apply'd hot thereto. It likewise has the virtue of destroying worms in the body; and being taken in the quantity of half an ounce, with a draught of warm water, or small beer, it proves an excellent sudorific in the plague. But in the putrid scurvy, and other common cases, no more than two drams need be given for a dose, to be repeated occasionally; and in such a quantity as this, or, if there be occasion, a greater, it proves a mild and safe cathartic, proper in continual fevers; as being a fine acid, aromatic and oily solutive medicine. But when a burning fever is, as it frequently happens, attended with an alkaline corruption, and great viscosity of the humors, this acid and deobstruent elixir is truly admirable. 'Tis also a powerful medicine, when externally us'd, in putting a stop to a gangreen; for being apply'd hot to the part, with linen rags, it will soon procure a suppuration: and these are virtues, to give it its just character, of which this medicine is really possess'd.

PROCESS LXXII.

Exhibiting the manner of preparing ELIXIRS with fix'd alkali and distill'd waters, by an example in Elixir Proprietatis.

1. **T**O the ingredients mention'd in the preceding process, pour such a quantity of oil of tartar per deliquium, as will make them into a mass of the consistence of thick panada; and digest them together, in a tall glass, with a gentle heat, for the space of four and twenty hours; then add about twelve times their quantity of any distill'd aromatic water, at pleasure; for instance, that of cloves or mint; or so much as will reach the breadth of three fingers above the ingredients; and boil them together for twenty four hours longer, and the elixir required will be obtained. The process.

2. It might perhaps be a better method, tho more tedious, of preparing this elixir, by first digesting the ingredients with the oil of tartar, in a flat-bottom'd vessel with low sides; then boiling the matter over a gentle fire, till it becomes almost dry; and afterwards exposing it to the moist air of a cellar, that it may again run *per deliquium*, and again be exhaled and dry'd as before; and lastly digested with the distill'd water: for by this means there would be made a total solution of the ingredients, excepting only a few fæces. If instead of the distill'd water in this process, there be used spirit of wine once rectify'd, a more heating and sudorific, but less purgative elixir will be obtain'd, or, as it were, a balsam prepared with Harvey's tincture of salt of tartar: for the liquor in this case will be thick, almost like oil; as containing the gummy and gross resinous parts of the ingredients; whereas pure alcohol would draw out only the finer. Other ways of performing it.

3. The virtues of this tincture, allowing for the difference of the menstruum, are the same with those of the elixir of the preceding process. The medicinal uses of the preparation. 'Tis subject to one inconvenience, that of turning mouldy by keeping; otherwise it might be made and prescrib'd to as good advantage as that; and in all the same diseases, provided they proceed from a contrary cause; or whenever austere, acid, or cold phlegmatic humors predominate in the body. It is aperitive, attenuating, dissolving, stimulating, cathartic, diuretic, sudorific, vulnerary, &c. But where the humors of the body are already dissolv'd down, or their texture broken, as in the plague, malignant fevers, &c. it ought never to be given; for in these cases it is highly pernicious. But in such obstructions of the menstrual flux as happen in a phlegmy habit, oppress'd with a peccant acid, it is of very great service; being taken, in a proper dose, for a considerable time together. In short, this elixir is convertible into a medicine of almost any virtues, according as it shall be determin'd by the menstruum.

struum. Thus it may be made to act entirely as a sudorific, purgative, diuretic, &c. by preparing it with suitable distill'd waters of certain vegetables, or by the admixture of other medicines, respectively endow'd with those virtues.

PROCESS LXXIII.

Exhibiting the manner of preparing ELIXIRS with alcohol and fix'd alkali, by an example in Elixir Proprietatis.

The process.

1. **R**educe an equal quantity of myrrh and aloes to fine powder, and pour upon them twice their own weight of oil of tartar per deliquium; then digest them in a low, broad-bottom'd vessel, for four and twenty hours, with a gentle heat; at length increasing the fire, till the matter becomes nearly dry: then let it run again by the moisture of the air; and after that digest and exhale it again to a dry mass; which being put into a tall glass, add thereto half as much saffron as was taken either of myrrh or aloes, and pour to them such a quantity of pure alcohol as will rise the breadth of three or four fingers above their upper surface; then boil them gently all together, for four and twenty hours: and lastly, when the glass is cold, pour off the clear tincture from the ingredients. And thus the elixir will be made, tho the ingredients are not all dissolv'd, or totally depriv'd of their virtue.

Its chemical and medicinal uses.

2. We may learn from this experiment, that alcohol is not always the best menstruum with which to extract tinctures, or take up the virtues of ingredients; for here the elixir is much thinner, and more diluted in its colour, than in the preceding process, when a spirit let down with a proportion of water was employ'd; or than it would be if drawn with spirit of wine that hath been but once rectify'd. This elixir, however, is of an exceedingly penetrative, aperitive, resolving, attenuating, and stimulating nature, but less purgative and more heating than those before describ'd. It is also sudorific, diuretic, and proper in those diseases which require balsamic alkalies for their cure; as the muriatic scurvy, the green-sickness, universal dropsy, &c. It may be conveniently exhibited, from the quantity of half a dram to half an ounce for a dose, along with some proper syrup. It is also generally recommended for the cure of external ulcers, tho of long standing, without the assistance of plaisters; especially when a mucous humor, or ichor, distills from the ruptured lymphatics: but as it deterges powerfully, when the ulcer is once thorowly cleansed the medicine should afterwards be mixed with water; and by this means it may be made into a cicatrizing and consolidating, as it is of it self an escharotic and detergent remedy: so that even fistula's may be healed up by it; if it can but, by the management of the dressings, be apply'd to the bottom thereof. In the same manner, it is of excellent use in case of carious bones; as serving to stop the growing mischief, and preserve them from farther putrefaction.

Internal

Internal purulent ulcers are likewise cured by the internal use of this medicine: for which reason, 'tis highly valued both by surgeons and physicians. 'Tis also possess'd of an embalming virtue, like the balsam of the antients; whence it preserves dead bodies from corruption, by strongly binding up the solids, and thickening the fluids thereof: so that for practical uses we could be without almost any medicine rather than this.

P R O C E S S LXXIV.

Exhibiting the manner of preparing ELIXIRS with rectified spirit of wine and soluble tartar, by an example in Elixir Proprietatis.

1. **I**F instead of oil of tartar, in the preceding process, the liquor of tar- The process.
tariz'd tartar be substituted, and the process be carry'd on exactly in the same manner as is there describ'd, but with rectified spirit of wine, a much thicker elixir will be procured, of a neutral nature as to acid and alkali, and more impregnated than the former with the virtues of the ingredients, which here are almost entirely dissolv'd.

2. The myrrh and aloes, by being digested, dry'd and treated with Excellence of the preparation.
the soluble tartar, as the process requires, will be totally converted with it into one saponaceous mass; almost the whole whereof will be readily taken up by the spirit of wine, and suffer no alteration in its virtue from the mixture either of acids or alkalies: for which reason, this cannot but be the best method hitherto exhibited of making the *elixir proprietatis*; which, thus prepared, may be safely given in doubtful distempers, where we are not certain whether an alkali or an acid prevails in the body; without observing any particular cautions which in other cases must of necessity be regarded. It is principally useful in hypochondriacal cases, and where the bile is so thick as to require diluting, or to have its texture open'd. But if, instead of the spirit of wine, any distill'd water, suitable to the intention of cure, be made choice of for the menstruum in this process, we may readily obtain a most noble elixir, to be given in any distemper with the utmost safety.

PROCESS LXXV.

Exhibiting the manner of preparing ELIXIRS with alcohol and regenerated tartar, by an example in Elixir Proprietatis.

The process.

I. **T**O equal quantities of myrrh and aloes, reduced to fine powder, pour as much liquor of regenerated tartar as will serve to reduce them into a thickish fluid mass; which is to be digested a while, with a gentle heat, the matter being kept continually stirring, till it appears entirely dissolved: then put to it a quantity of saffron, reduc'd to fine powder, equal to that either of the myrrh or aloes, and three or four times as much alcohol as there was liquor of regenerated tartar: then boil them softly together for half an hour; by which means there will be procured a noble, and thick balsamic elixir, containing almost the whole substance of the ingredients; a very small proportion of faces remaining behind, after the clear liquor is decanted.

Its excellence.

2. This process shews us a short, cheap, and easy method of making the most noble and efficacious elixirs that can be hoped for in medicine; especially, if instead of alcohol we use only spirit of wine; as might be done to good advantage: for in this elixir, the fix'd salt of tartar being render'd volatile, and set loose, seems to exert those virtues and powers which *Helmont* so amply extols in volatiliz'd salt of tartar, both upon the human body as a medicine, and several stubborn and untractable substances as a menstruum. And in effect it is a most penetrative, saponaceous, and balsamic liquor, not to be exceeded by any thing of the same nature.

3. It is to be observ'd, that all these processes for the preparation of *elixir proprietatis* are no less general than the rest, tho they may seem particular, and limited but to three ingredients; for if other gums were used instead of myrrh and aloes, the processes would hold equally good.

CHE-

CHEMICAL HISTORY of AMBER.

PROCESS LXXVI.

Exhibiting the manner of analyzing bodies, in order to discover of what kingdom they are, by an example in that controverted subject AMBER.

1. **F**ILL two thirds of a coated retort with amber, brought into small lumps The process. by the mortar; then fill it up to the neck with clean dry sand; fit it with a large receiver, that lying almost horizontal, may let the vapors come over freely; and lute the juncture. The retort being placed in a sand-furnace, let the fire at first be made only so strong as to cause a dew upon the receiver, and make the liquor just begin to drop: continue this mild degree of heat till all the aqueous, spirituous and acid liquor is come over, or till it will cause no more to rise. (2.) Then increase the fire till another liquor begins to rise, or till white fumes appear in the glass, and the receiver grows warm. Carefully keep up this degree of heat as long as any liquor will run therewith; otherwise the receiver, how large soever it be, will crack. By this means there will be brought over a fine, transparent, ponderous, yellow oil, of a penetrating nature, almost like oil of petre. And when this has almost ceas'd to run, a white, transparent, perfectly acid, and almost solid salt, will fix it self in the neck of the retort, and sides of the receiver; being the only thing of this kind in nature, and capable of flowing at the fire, dissolving in water*, and shooting into the form of a firm white glebe. (3.) The fire being now again augmented, there comes over a very thick kind of oil, of the nature of petroleum, and lighter than the former; but if a fire suppression be made, it becomes heavier than that; nothing but a gross, viscid, black, pitchy matter, like colophony, remaining behind at the bottom of the retort; and this likewise, by continuing the operation, may almost totally be brought over in the form of that thick gross oil, which, when cold and dried, appears like bitumen†.

* This salt is likewise said to be the only one that is readily dissolvable in spirit of wine; which is therefore commonly esteem'd the criterion of its purity. The price hereof being large, 'tis a great temptation for the chemical dealers to adulterate it with cheaper salts; *ol. succini, sal ammoniac, sal Elisham.* &c.

† The process for analyzing amber is variously describ'd by chemical authors; some, as Glaſer, Charas, le Febvre, le Mort, Vigani, Lemery, &c. advising the subject to be distill'd

with, and others without an addition; these with, and those without pulverization; some with, and others without luting the receiver, rectifying the spirit, oil, salt, &c. One is for a sand-heat, another for a naked fire; one for a large yellow amber, another for a small and white one; with other variations too tedious to enumerate. It may, with a tolerable degree of skill, be managed to advantage in the manner here described, with very little trouble.

How improved.

2. By rectifying, or distilling over again, the several parcels of liquid afforded in this operation, they may be separated and obtained more pure than they rise at first; so that the water and spirit, or acid liquor, now rise distinct, the odd kind of salt shoots afresh to the sides of the glass, and all of them appear possess'd of a penetrating balsamic virtue.

Its uses in chemistry and natural philosophy.

3. We learn from this experiment, (1.) That acid salts, as well as the alkaline, may exist in the solid form of crystal. (2.) That the hard, dry, and almost glassy body of amber, is resolvable into water, spirit, salt and oil. And, (3.) That this strange substance, tho it belongs to the vegetable, greatly resembles a subject of the mineral kingdom; for amber dissolves in alcohol but not in water, melts at the fire, and is inflammable: so that it might very well pass for a species of sulphur, or bitumen. 'Tis indeed a wonderful substance, whose origin is not yet sufficiently known *, tho most probably a vegetable; as we may fairly conjecture from our present process: since it may be resolved into the same parts with vegetables; viz. water, spirit, salt, and oil; and possibly not unlike the camphire of *Asia*, which, being the concreted oil of the aromatic plants of that country, affords us an example that oils elaborated by a great degree of heat may appear in a crystalline form.

Its uses in medicine.

4. The acid volatile salt obtain'd in our analysis, being purify'd by sublimation, and separated from its oil, becomes very white, and affords us one of the best diuretics hitherto known in medicine. And the fine yellow oil, by rectification †, becomes a noble antihysterical and emmenagogic, no less subtle than *petroleum*.

* That amber is really no more than a concreted resinous juice, which originally proceeds from vegetables, is made very probable by the learned naturalist *Pliny*, and confirm'd by *F. Camelli*, who himself has seen large pieces of it brought down from certain mountains in the *Indies*: and the like, he says, is found in

a fluid form in several of the *Eastern* provinces, where it is called by different names: See *Philosoph. Transact.* N^o 290. *Plin. Nat. Hist.* lib. xxxvii. cap. 3.

† This is the best sort of oil of amber, commonly sold in the shops.

CHEMICAL HISTORY of VEGETABLE PUTREFACTION.

PROCESS LXXVII.

Exhibiting the phenomena of Vegetable Putrefaction, with its various effects, or the manner of converting vegetable into animal substances.

1. **T**HROW together any of the tender, green, and succulent parts of recent vegetables, whether acid or alkaline, in a large heap, in the warm open air, and press them down with an additional weight, if their own be inconsiderable; and the middle part of the heap will, in a little time, spontaneously conceive a small degree of heat, and pass successively thro' the other degrees, till it comes to a state of ebullition. In the space of three days, from the first putting them together, they will yield a heat, perceivable by the hand, equal to that of the human body in a state of health; by the fifth it will be too great for the hand to bear without pain; and lastly, by the sixth, seventh, or eighth day, the juices will generally appear ready to boil, and sometimes the matter will even flame and burn away. (2.) By this spontaneous operation, the vegetable acquires an abominably putrid, stercoraceous, or cadaverous, taste and odour; and turns entirely into one soft, similar, pappy mass, or crassamentum, greatly resembling fetid human excrement in scent, and putrefied flesh in taste. (3.) If now this fetid matter, thus obtain'd, be directly, whilst it remains in its fetid state, committed to a glass retort, and distill'd with proper degrees of fire, there will come over, 1st, A water impregnated with an urinous spirit, perfectly like that obtainable from animal subjects, and separable by a fresh distillation, slowly made in a tall glass, into elementary water, and a large quantity of pure, white, volatile, dry alkaline salt, not to be distinguished from animal salts. 2dly, A volatile, alkaline, oily salt, that shoots in glebes. 3dly, An exceedingly volatile and a thick fetid oil, both which are also entirely like those of animals. 4thly and lastly, the remainder being calcin'd in an open fire, affords not the least particle of fix'd salt; just as if the subject had really been of the animal, and not of the vegetable kingdom.

2. This process is truly universal, and holds equally in all kinds of vegetables, tho ever so different in their nature and virtue. I have my self made the experiment in the coldest and most succulent or watry plants, such as purslain, sorrel, &c. as well as with the hottest or most acrimonious, such as the sparges, &c. and always found it succeed; but the sooner, as the vegetable employ'd contain'd the greater quantity

tity of oil; tho with the same phenomena. It will likewise succeed with dry vegetables; provided they be moisten'd with water before they are thrown into heaps. And thus we sometimes see that stacks of hay will spontaneously take fire and blaze away; especially if it was not well dried in the making. It is a very surprizing thing to consider, that by this means the difference betwixt vegetables may be entirely taken away, and the whole kingdom of them reduced to the same common nature; so that wormwood and tansey, for instance, or sorrel and scurvy-grass, shall appear as one and the same thing; and this thing appear no otherwise than putrefied flesh. Tho sorrel be famed for its power of preserving the animal fluids uncorrupted, whilst they are circulating in the body, and scordium for its embalming virtue, as continuing it in a state of incorruption after death; yet even these plants are themselves thus easily corrupted, and changed into such a kind of putrefied flesh as it is their virtue to prevent. And this is a general law of nature, wisely establish'd to produce wonderful changes in the world, and to prevent the indolence and decrease of matter on our globe; this active principle, or medium, giving an easy and reciprocal transition of vegetable into animal substances, and animal into vegetable.

Its use in explaining the difference between fermentation and putrefaction.

3. Hence then we are given to understand the nature and uses of putrefaction, with its difference from fermentation, both in regard of the subject, cause, and effect. Vegetables alone are the subject of fermentation; but both vegetables and animals of putrefaction. Fermentation also requires that its subject be first reduced to the form of a liquid, or at least made capable of floating in one, before it can obtain; whereas putrefaction only succeeds when its subject is half dry, or just barely moist: and this is the reason why must put up into a wooden vessel, does not putrefy; whilst the grapes, from which it was express'd, being thrown in heaps, would presently conceive heat, and run into a state of putrefaction. We see also that vegetable putrefaction is begun and promoted with heat, and finished with coction, which requires a degree of heat much greater than that excited by fermentation, as being capable of causing an ebullition in the plant, and even of turning it into flame: and indeed the immediate cause of fermentation is the motion of the air intercepted between the fluid and viscous parts of the fermenting liquor; but the cause of putrefaction is fire it self, collected or included within the putrefying subject. Again, the effects of fermentation are the production of flowers or yeast, the conversion of the saline part of the fermenting body into tartar, or an acrimonious acid and fix'd kind of salt, and of oils into inflammable spirit, retaining something of the nature of the vegetable; but putrefaction makes all the acid salts volatile and alkaline, renders the oils not spirituous but abominably fetid, utterly destroys what sets the specific difference between one subject and another, and converts them wholly into a soft pulpy mass, of an animal nature, without the least signs of

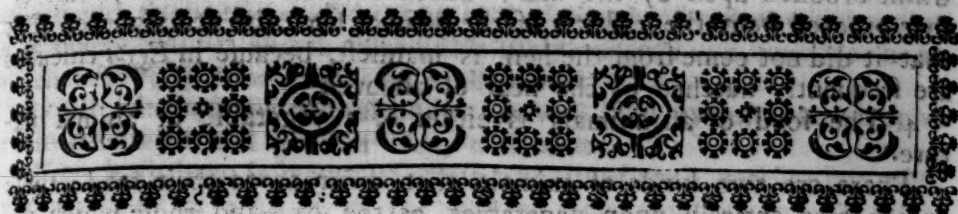
any fix'd salt; tho the recent vegetable would, by calcination, at first have afforded a large proportion: or in short, making nearly the same kind of alteration in the whole subject, as it would undergo by passing thro' a sound animal body, suffering all the actions thereof, and being at length returned in the form of excrement. And this may let us a little into the nature of animal digestion, or the change which the aliment suffers in the human body. It is certain, that tho a man should live entirely upon acid vegetables, eat acid bread and fruits, and drink nothing but *Rhenish* wine, that no part of his body, as the flesh, blood, bones, &c. or its excrements, as the urine, sweat, faeces, &c. would afford the least portion of an acid, or fixed salt, by distillation, but constantly a volatile alkali, by whatever contrivance the experiment is fairly made; and this in as great perfection as if the aliment taken in had been putrefied, and analyzed in the same manner: whence, if animal digestion be referable to any chemical operation, it ought doubtless to be that of putrefaction, rather than fermentation. But to say the truth, there is never any perfect putrefaction performed in the living bodies of animals; for as soon as any thing contained therein, has a tendency to this alteration, it is immediately discharged, along with the excrements, as by stool or urine. All the acids of the aliment are therefore subdued by the vital powers of animals, and converted into volatile salts of an alkaline nature; yet without a real or actual putrefaction, tho by an operation that nearly approaches to it. The salts and oils thus taken into the blood, and mix'd with the juices, are detain'd in the body so long as they remain benign and friendly to it; but, as we said before, when once they alter their nature, or begin to putrefy, they are immediately thrown off; as may appear by the sharpness, fetid scent, and particular examination of the urine in such cases: otherwise grievous distempers would be excited, that must of necessity soon end in the death of the animal.

4. And now we have gone thro' all the general and fundamental *Recapitulation.* processes, which can assist and forward our inquiries into the subjects of the vegetable kingdom; and according to which all of the like kind ought to be conducted. We have seen the several methods of distilling waters, their differences, and upon what principles their virtues depend; we have seen all the ways of extracting, separating and making infusions, decoctions, sapa's, defruta, extracts, salts, oils, balsams, rosins, spirits, vinegars, fixed alkali, earth, &c. and of procuring all that the fire will obtain from vegetables, by the various treatments or operations practised among chemists; we have also seen the effects of different combinations of these simple productions, and what may, by this method, be obtained; viz. tinctures, quintessences, soaps, elixirs, &c. by exhalation, decoction, extraction, crystallization, and calcination; and lastly, we have seen that strange effect of fire, putrefaction. And thus, in one word, to recapitulate what we have been doing by an example, if we would

procure all the active powers of any vegetable, as of rosemary, for instance, we are taught, by the preceding processes, to exhale, and catch its vapour, get its essential oil by distillation, its native salt by expression and crystallization, its fixed salt by calcination, its inflammable spirit by fermentation, its tincture or elixir by composition and digestion; and lastly, its animal principles by means of putrefaction.

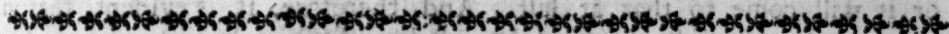


S E C T.



S E C T. II.

Exhibiting a Course of PROCESSES upon ANIMALS; the more compound Class of Organical Bodies.



PRELIMINARIES.

1.  **E**FORE we enter upon the chemical analysis of animals, there are some general and fundamental propositions to be laid down from the principles of medicine; the truth whereof is so clear and well established, that they may falsely pass for axioms.

2. The bodies of living animals are continually wasting and repairing in all their parts.

This proposition is so clear, as not to admit of a doubt. The truth of it is evident, even in the hardest and most solid parts of animal bodies. The nails and hairs which are once cut, soon grow to their former length; the bones that were broken, join together again in a few days time; and the teeth, and all other solid parts wear by frequent use, tho no sensible diminution is found of their substance. But if the solids thus constantly fly off and recruit again, the fluids must unquestionably do so too. And in effect we see that animal bodies increase every way, from the smallest physical point till they arrive at their full size.

3. Animals, therefore, must necessarily be composed of what they take in as aliment; which, by their vital powers, is converted into their own substance.

Perhaps also the bodies of animals may receive part of their aliment from the air; for, as *Malpighi* has curiously observed, eggs gain in weight whilst

Processes upon Animals.

whilst brooded upon by the hen; which addition of matter, must either proceed from the effluvia of the hen, or from the atmosphere. But that it did not come from the hen, is manifest, because in *Egypt* chickens are frequently hatched by the heat of an oven.

4. The food of all animals is either of a vegetable or animal nature.

There are two kinds of animals, that differ as to their food; those which feed entirely upon vegetables, as the ox; and those which devour the flesh of other creatures, as the lion: but man is an animal of an indifferent kind, that can support himself either with vegetables or flesh, alone. Thus there have been those among the *Pythagoreans* and *Brachmans*, who entirely liv'd upon vegetables; as being obliged by oath to eat no kind of animal.

5. The bodies of all animals, therefore, and even those of men, consist either mediately or immediately of vegetables.

The greatest part of the animals which men use for food, are themselves immediately fed with nothing but vegetables; as sheep, oxen, rabbits, &c. But fish, indeed, often take down insects, and so do some kinds of fowl; but then those insects were either fed with vegetables, or it will come to that at last. And, therefore, it is evident, that in order to have a just chemical knowledge of animals, we ought to begin our analysis with vegetables, of which they consist; and this we have done in the preceding processes, to lay the foundation for those which are to follow. A neglect of this observation has introduced a deal of confusion into the writings of chemists and their courses.

6. The method, therefore, in which we are farther to proceed, requires us first to analyze that part of animals which has received the least alteration in their bodies, or but just begins to lose its vegetable, and put on an animal nature.

7. This part must be such a fluid, as proceeding originally from a vegetable, has felt the vital forces of the body, mixed with the blood, passed thro' the arteries and the veins, and been soon separated again. And this can be no other than chyle from vegetables, turned to milk, and separated in the breasts.

It would be improper here to make choice of the chyle it self; this being plainly a vegetable juice, as not having been yet receiv'd into the body, circulated along with the blood, or participating of the nature of an animal fluid. The excrement could not be chose for this purpose, because it loses its vegetable nature in the intestines; and besides, is really no part of the animal body, as having never past the heart, or circulated with the blood. Nor has any other fluid in the body so good a title to our first experiment upon animals, as the milk; this being only animal in the first degree, and differing but one remove from chyle it self, which may well be esteemed a vegetable. But if, instead of this primary animal fluid, we should begin our future processes, as all the famous chemists have done, with analyzing the flesh, the horns,

or

or the hoofs of animals, which are among the last productions of nature, we should strangely break in upon that delicacy of order which makes a principal beauty, and is indeed absolutely required in a course or body of chemistry, that should be generally useful.

8. All the parts of animal bodies, as well solid as fluid, may receive their nutriment and growth from milk alone.

There have been instances of those who lived upon nothing but milk; and the body of a child, at the end of some months after its birth, is little more than a composition of the milk of the mother; the parts it brought with it into the world being changed for others supplied by the nutriment, in the same manner as the body of an ox is a composition of grass. Thus, by the vital actions, the milk is made to pass thro' all the changes of blood, serum, lymph, nervous fluid or animal spirits, which seem to be the immediate matter of nutrition to all the solids*.

9. The milk of such animals as are only fed with vegetables, being drawn from the breast, and permitted to stand in a warm place, soon separates, of its own accord, into a light and white kind of oil, which rises to the top, and is called cream; and into a thinner, aqueous, bluer, and more ponderous liquor, vulgarly call'd, when the cream is taken off, by the name of skimmed milk.

The milk of the several kinds of animals differs but little, as to its smell, taste and other properties; but that drawn from the breasts of women is the sweetest; the nearest whereto is asses milk, which indeed has a saccharine sweetness, and comes almost up to the human. This is succeeded in virtue and goodness by that of mares, which is better than that of goats; yet even this exceeds that of sheep, as theirs does that of cows, which is the coarsest of all.

10. Neither of the two parts into which new milk spontaneously separates, is of it self either acid, alkaline, or acrimonious, to the smell or taste.

It is true, indeed, that these parts turn acid by standing for some time; but this does not infer, that, contrary to all the evidence of our senses, they naturally contain any acid. Neither are they in the least acrimonious; for being let fall into the eye, they cause no manner of pain, or sensation of sharpness.

11. From these axioms, or general truths, we may draw the following corollaries, which are no less certain than they. (1.) All the parts of the human body might once materially exist in the form of milk. (2.) Chyle, tho really a vegetable fluid, is an imperfect milk, or the rudiments and basis thereof; and exhibits many of the pheno-

* This the learned author has, by an elaborate chain of arguments, in his admirable *Institutiones Medice*, made to appear very plausible, but it is question'd whether the actual existence of animal spirits has been sufficiently proved to cause such an hypothesis to be relied on. A close attention to the thing, will perhaps discover, that nutrition, and other actions of the body, may be accounted for without pressing animal spirits into the service.

mena afforded by vegetables; particularly in its flatulency, the effervescencies it occasions, &c. (3.) Milk is a kind of emulsion, or white oily, animal liquor, prepared originally from vegetables by mastication mixing with the *saliva*, the bile, the pancreatic juice, the blood, circulating with it, and being at length separated from it in the breasts. It differs, however, from a true vegetable emulsion in two respects; *viz.* first by coagulating into a curdy matter with acids, capable of forming cheese; which chyle, and all true emulsions, will not do; the utmost that acids can here procure being a raphaceous or chalky kind of substance, but never a cheesy matter; and secondly, acids precipitate a larger quantity out of it than they can do out of emulsions. These particulars being premised, we may proceed to our experiments upon animals.

CHEMICAL HISTORY of MILK.

P R O C E S S LXXVIII.

Proving that new MILK is neither acid nor alkaline.

The process.

1. **T**O any quantity of warm new milk, pour oil of tartar per deliquium, or any other alkali, and no effervescence will at all be thereby excited, but the whole body of the liquor remain at rest, tho' it appear somewhat thinner. (2.) To another quantity of warm new milk, pour, in the same manner, spirit of nitre, or any other strong acid; and again no motion or ebullition will appear; only the milk will presently after become thicker than it was. (3.) Now mix together the two parcels of the milk with which the experiments were made, and a great effervescence will immediately arise.

The truth it is designed to manifest, confirmed.

2. The phenomena and effects will be the same, whatever alkalies or acids, even tho' of the strongest kind, are pour'd to the milk: whence we may fairly conclude, that new milk contains neither acid nor alkali; for if either of these were latent in it, the process ought to make the discovery, as being generally allow'd the proper criterion. And, accordingly, in the latter part of the experiment, when the two parcels of milk, containing the one an alkali, and the other an acid, come to be mix'd together, these presently manifest themselves by the conflict they make. And thus also, by the common trials with syrup of violets, or the like, mix'd with new milk, no acid or alkaline parts can, from a change of colour in the syrup, be discover'd, any more than by the direct examination of the senses: if, therefore, any one after this, shall

shall say that new milk is acid, because it may be made so by art, or turns sour of its own accord by standing, he may, with as much justice, pretend that there is alkali contain'd in vinegar, tho no signs of it appear; because alkali may be naturally or artificially obtained from it. But this is changing the nature of things, and retaining their names; for in such a case, milk is no longer milk, nor vinegar the thing that its name implies.

PROCESS LXXIX.

Shewing that MILK turns acid by Digestion.

1. **L**ET any quantity of new milk, drawn from a sound animal, that feeds only upon vegetables, at the distance of about eight hours from her feeding, stand to digest in a clean, open vessel of glass, with a heat equal to that of a man in health, and it will soon begin to throw up to its surface a thick, unctuous, creamy or butyraceous part, which will thus rise in a considerable quantity; a much larger proportion of a thinner or serous liquor remaining below. Both of them at first are sweet to the taste, or manifest no kind of acidity; but by degrees they both turn tart; and at the end of twelve days, from the first of the operation, attain their highest degree of acidity, which is very considerable.

2. This process will be the sooner finished in summer, by reason, as well of the additional warmth, as of the tart, juicy herbage whereon the cattle feed in that season of the year; but it proceeds slower in the winter, when they feed on hay: yet, even in this cold season, it will at length succeed. But if the milk for this experiment be drawn from such animals as feed solely upon flesh, or have been withheld from food for twenty-four hours, such as labour under feverish disorders, or have just before performed some extraordinary motion, or undergone hard labour, it will rather putrefy, or turn rancid, and run into ichor, than change of an acid nature. One of the first signs of this disposition, is its saline taste; so that it always may be concluded, that when milk is brackish upon the tongue, it then begins to putrefy.

PROCESS LXXX.

Shewing that boiling MILK will strongly coagulate with acids.

1. **G**Radually pour spirit of nitre, or any other acid, to a quantity of milk boiling over the fire, and no conflict will be made thereby; but the liquor will presently divide into two very different parts, the one thinner, and the other much thicker than milk, notwithstanding the action of the fire upon the matter.

2. The

Its physical use.

102. The effect is found to be the same in all the kinds of milk yet known; which by this means are formed into curd, whereof cheese is made; and a clear thin liquor, or serum, which now turns spontaneously acid. The coagulum formed upon this separation, may, by pressure and the evaporation of its moisture, in time be reduced almost to the hardness of stone; as we see in some particular sorts of cheese: so that it is no wonder that bones made out of milk are of that strength and solidity we find them. Something of this kind will also happen in emulsions, but in a less degree; for which reason, when we prescribe emulsions, we should be cautious not to mix acids along with them.

Its medicinal use.

3. This process may serve to shew us in what cases or constitutions it will be improper to use milk: for if it should be taken by persons whose bodies abound with acids, the same thing will necessarily happen there as did in our experiment; that is, the milk will be separated into a thin, serous fluid, and a strong coagulum, which, turning grumous, may cause obstructions in the viscera; whilst it ceases to be mixed and diluted with the serum, that instead of performing this office, may now go away in fetid sweat, leaving the body pale, faint, and weak. And this unheeded cause may give birth to a pale complexion, a cacochymia, and various chronic diseases.

PROCESS LXXXI.

Shewing that MILK turns red by being boiled with alkalies.

The process.

1. **I**F to a quantity of new milk, made boiling hot by the fire, any fixed alkali, as the salt of tartar, or its oil run per deliquium, be added by degrees, there will a lighter kind of coagulum be made than was before produced by the acid; and the milk, by boiling, will presently change to a yellow colour, and run thro' all the intermediate degrees, till at length it stops in an intense red.

Its physical uses.

2. The coagulum, and changes of colour, will be the stronger and more suddenly made in proportion to the strength of the alkali, and continuance of the ebullition. Whence we may see that milk has a very great propensity to turn from its native white, into a red colour. The milk of all animals, in a state of health, is naturally white; whatever be the colour of the aliment they take in; and will exhibit the same phenomena by the treatment of this process: or if the alkali be very strong, and the operation continued long, it will change at length into a dusky red, or dark brown, and even a black colour. Whence it is easy to see why the chyle so readily changes into a red liquor, or blood; for the animal juices, with which it mixes in the body, contain no acid, but rather incline to an alkaline nature. And when any animal, that gives suck, becomes feverish, the milk turns from its genuine whiteness to a yellow, and becomes, in a manner, sanious and coagulated. When the milk of

a nurse is in this state, the infant manifests a very great aversion to and dislike of it: and if the fever continues long, the breasts grow hard, and at length impostumate, so as to prove of difficult cure. The generality of physicians will needs have these disorders to proceed from a certain, imaginary, peccant acid in the body; when nothing can be plainer, as may be learnt from our present process, than that they are owing to the action of an alkali. And hence it was, that in the terrible contagion which happened among the cows in *Holland*, in the year 1714, their milk proved exceeding thick, yellow, and almost putrefied, before it came from them. And what is very surprizing, this change was made in it so suddenly, that a country-man, of whom I had but the evening before purchased some pure, white milk for chemical experiments, complain'd to me the very next morning, that he could now get nothing from the same cow but a thick, pappy, yellow matter, instead of milk.

3. What we have hitherto shewn of milk holds true, provided it be drawn from any of those animals that feed entirely upon vegetables; and at a time when they are in a state of health: but if the creature which afforded the milk, labours under any violent distemper, either of an acid or putrid nature, the phænomena will be quite different. And the same must be expected, if the animal that gave the milk feeds only upon animals. The physicians who prescribe to the diseases of infants, ought carefully to regard these observations; for if a nurse should entirely abstain from acid vegetables, as wine, malt-liquors, &c. and use only water, or the decoction of animal substances, for her drink, and feed upon nothing but the flesh of animals, as fish, &c. her milk would scarce be capable of turning sour, but would rather putrefy and smell strong like urine; and the child that drew her breast, would never be free from a fever: which is too often the case of the infants of wealthy parents; the nurse being preposterously withheld, by the tender mother, from the use of whatever food is of an acid nature; and confined to live altogether upon animal diet, as the most nutrimental. On the contrary, the children of the poor, whose mothers are principally sustain'd by food of an acid nature, or what in some measure inclines thereto, are much less subject to fevers; but oftener afflicted with those diseases which owe their rise to acids. The cure of both cases is best effected by a change of diet in the nurse, from alkaline to acid, or from acid to alkaline. Thus when the diseases of young children proceed from an acid cause, which may be learnt from the scent of their fæces and eructations, as also from a preternatural distension of the body, and paleness of the flesh, the diet of the nurse should consist of fish, flesh, and the liquor in which they are boiled; the use of bread, wine, and other things of an acid nature, being forborn. But if the infant labours under a burning fever, appears red, hot, &c. the nurse should be treated in the contrary manner, with acids, or such aliment as is tart and cooling. And thus we are taught the nature of that liquor of

which the human body may be entirely composed ; and which receives so sudden an alteration therein, that no signs of it can be found twelve hours after it is once admitted into the blood ; as the excellent Dr. *Lower* has shewn by experiment. Upon which account no woman that gives suck ought to fast above twelve hours, if she would afford good milk to the infant at her breast. Hence, likewise, we are given to see the reason of some phenomena both in acute and chronic diseases ; as particularly the redness and heat of the body in the former, and its paleness, &c. in the latter ; these generally proceeding from an acid, and those from an alkaline cause. And hence, lastly, we learn a necessary caution in the choice of a nurse ; *viz.* that her milk be perfectly white ; a tendency to yellowness in it being a sure and early symptom of a fever.

*Introduction to
the history of
urine.*

4. Our method next leads us to examine that fluid, which of all those in the animal body, is first secreted after it has undergone an entire course of circulation thro' the vessels and viscera. And this we pronounce to be the urine of a sound animal, discharged at the distance of twelve hours from taking any thing by way of sustenance ; the bladder also having just before that time been emptied of its contents. We do not make choice of the blood for our next experiments, because all its parts are too confusedly blended and locked into one another to be fit for this purpose ; whereas in urine, the oils, salts, spirit and earth hang looser together ; having but just entirely put on an animal nature, by which, however, it is perfectly distinguish'd, and made widely to differ from vegetables.

CHEMICAL HISTORY of URINE.

P R O C E S S LXXXII.

Shewing that URINE is neither acid nor alkaline.

The process.

1. **T**AKE any quantity of fresh urine, that has not been above twelve hours contained in the bladder, and add to it oil of vitriol, or any other acid liquor, at discretion ; and no manner of conflict or effervescence will be made between them. In like manner, add to another parcel, oil of tartar per deliquium, or any other known alkali, and the mixture will lie quiet as before, or give not the least signs of any ebullition : whence it may be justly inferred, that such urine is neither acid nor alkaline ; as standing the test of the experiment allowed sufficient to make the discovery.

2. The urine made choice of for this experiment, ought to be that of the morning, or discharged at the distance of twelve hours after any meal, that it may be a perfect animal fluid: nor should it be suffered to remain for any longer time in the bladder, lest it might thereby begin, as it were, to putrefy, or acquire something of an alkaline nature. The bladder, therefore, should here be emptied before the last meal is made. But if the urine be taken twelve hours after feeding, it will then be perfect and thorowly concocted; no chyle, or matter of a vegetable nature, as was before observ'd, appearing in the blood, after the expiration of that time, without a fresh supply of food; so that the aliment then taken in, may now it is mixed with the blood, be justly esteemed a part of the body.

3. Human urine is a recrementitious liquor, confessedly drained from the whole mass of blood, after it has washed both the solids and fluids; and therefore cannot but excellently discover to us the nature of the salts contain'd in our bodies. Accordingly, if we examine it by our senses, we shall find it to the taste considerably more saline than the blood it self: but its scent, when fresh, is no ways nauseous or disagreeable, but somewhat grateful, pungent, and odoriferous. *Galen* tells us, "that the urine of a man in health is straw-colour'd, or of a pale yellow, and contains but little sediment, or fæculent matter; being in effect a lixivium, in which all the salts of the body are dissolved and washed away:" and indeed this appears to be the very fact. But if either alkaline or acid salts were naturally contain'd in the urine, our present process must needs make them manifest. But neither this, nor the common experiments made with the syrup of violets, &c. will discover such kind of salts in the urine of healthy persons; and therefore we must, in justice to our senses, as well as experiment, conclude it contains none. Nay, I have, in like manner, examin'd the urine of a man who had lain for twenty-four hours ill of a fever, without eating or drinking; yet could not, even in that, discover any signs of an alkali or acid salt, either by its making any effervescence with known alkalies or acids, or changing the blue colour of syrup of violets to red or green. With the same view I have strictly examin'd the urine of a man who liv'd almost entirely upon acids; but could find no proofs of acidity therein. And these experiments will hold true universally, where the urine is fresh, and procured in its natural state, or from healthy persons: but it must be expected, that a difference in circumstances will vary their success. Thus if a man should have a stone in his bladder, this might occasion the urine to appear of a more alkaline nature than if he had none; or drank scarce any thing more than acid wines or vinegar; especially if the urine be made and examined presently after the drinking of such acid liquors: for in that case, not having had their due circulation, they may in the form of urine still retain something of their prior nature. And so, likewise, in any diseased state of the body, the urine, or other humors, may change

Processes upon Animals.

from what they naturally are, and become either alkaline, as in a burning fever, near the point of death, &c. or acid, as in the *pallor virginum*, childrens diseases, &c. But it is not of such distempered urine that we are now speaking.

P R O C E S S LXXXIII.

Shewing, by the distillation of recent URINE, that the parts into which it is resolvable, are neither acid nor alkaline.

The process.

I. **T**AKE any quantity of fresh urine, obtain'd with the conditions above specified, and distil it gently in a clean, glass retort, with its receiver, and there will first rise a limpid water of a fetid or unpleasant scent; but resembling that of roasted flesh, containing neither a visible oil nor salt, and proving, upon the proper trials, neither acid nor alkaline, nor any way saline, or inflammable. (2.) If, after all this water is come over, what remains at the bottom of the retort be examin'd in the same manner, it gives no signs of its being either of an alkaline, or acid nature; and if distilled or exhaled still farther, as to the consistence of a syrup, or higher, it gradually changes its original straw-colour, to that of a yellow, a red, a brown, and lastly to a black, according to the quantity of water drawn from it, and appearing at length in the form of a saponaceous mass, that will not, like some other animal fluids, as the serum, white of eggs, &c. concreate by the fire. (3.) And lastly, if this soapy matter be calcin'd, it will afford a quantity of sea-salt, if the animal, or person from whom it was obtain'd, hath used any in his food: but if that be not the case, there will be no signs of any fix'd salt at all.

Its physical and medicinal uses.

2. The saliva, the serum, the bile, and other animal fluids distill'd in the same manner, afford a water of a somewhat unpleasant, indeed, but not a fetid odour, like that of our present process; as containing less oil, to which that scent is owing, and upon account whereof the liquor is perhaps said to be spirituous: nor does the urine of any other animals, fed with vegetables, so far as I have tried, yield such an one. And it is remarkable, that the more healthy and strong the man is, the more fetid this water distill'd from the urine proves; yet it appears not at all either of an acid, or alkaline nature, in any of the experiments I have ever made. We see likewise, that this water contains no inflammable spirit; whence it is manifest, that no such ever passes the urinary canals; tho fermented liquors are drank in very large quantities. For tho a man should take down four or five pints of wine at once, yet his urine distill'd at the distance of twelve hours from his drinking, would not appear in the least spirituous; but yield a very fetid water, like that afforded by the urine of a patient in a fever. I can speak positively in this case, because I have frequently distill'd the urine of great drinkers, on purpose to see what it afforded. And hence we may learn, how it comes to pass, that the drinking of strong liquors so remarkably affects the brain;

brain; and see the reason of the observation of *Hippocrates*, that great drinkers generally die apoplectic. Since therefore it appears, that there are no alkaline salts contain'd in the urine, we may justly conclude, that no such are contain'd in the human body, for if any alkaline salt did really, and in its own form, exist in the fluids of the body, it ought certainly to be found in the urine; because such salt joins it self with nothing more readily than water, which makes, as we see, a principal part of the urine; and therefore cannot but dilute, dissolve, and bring away with it the saline matter of the body. But altho neither alkaline, nor acid salts can be found in the human body, yet in ardent fevers, the plague, &c. the juices may, by the great increase of the circulation, and the violent heat, be turned of an alkaline nature; or become so sharp and corrosive, that unless they are discharged thro' the kidneys, they may presently destroy the tender fibres of the *cerebrum* and *cerebellum*, and so prove mortal. But if their subtil, or too much attenuated salts be determin'd to the bladder, along with the urine, the patient will from that time begin to recover; whilst the physician suffers the morbid matter to go off uninterrupted thro' the urinary passages. And indeed it were easy to conjecture, from the peculiar fetid scent of the urine, above that of all other fluids, that the kidneys are an organ design'd by nature to throw out of the body, any thing that, by being too much attenuated, cannot be longer detain'd with safety to the vessels of the brain, or the life of the individual. And therefore the urine, tho it has neither acid nor alkaline salts, yet actually contains the sharpest in all the body; being with the oil, which brings them to a kind of soap, of a very deterging nature. And accordingly, as they all come closer together in our experiment, by the evaporation of the aqueous parts, they appear of a deeper colour; just as in a fever, when the increas'd heat of the body has exhaled the more volatile or aqueous parts of the fluids, the urine becomes high colour'd, or intensely red, or sometimes even black: whence we may learn to prognosticate the turn of a distemper from the urine. This process likewise lets us see how contrary to truth that general opinion is, which supposes, fix'd alkalies, acid salts, or fermented spirits produced in the human body, to be the cause of all diseases.

P R O C E S S LXXXIV.

Shewing, by the distillation of recent URINE with dry sand, that it will afford a volatile, alkaline salt, &c.

1. **E**XHALE recent urine, over a gentle fire, to the consistence of a Syrup, *The process.* or thin honey; and afterwards add to it four times its own quantity of clean, dry sand, or so much as will reduce it to a thick paste; then distil this mass in a glass retort, of which it fills only two thirds, with degrees of fire, in a sand-furnace; and the first thing that comes over will be a large

Processes upon Animals.

large quantity of pure water or phlegm, as in the last process. (2.) Upon changing the retort, a transparent liquor ascends, and runs in veins, like oil, down the sides of the glass, called by the name of Spirit of Urine; which will cause a strong effervescence with acids; and by rectification resolve into a dry white salt, a water, and an oil. (3.) Upon continuing the fire, white fumes will next arise and fill the receiver; and at the same time, a large quantity of strong, volatile, alkaline salt will fix it self to the sides thereof; and this has been falsely supposed the same with sal-armoniac, which is not of an alkaline nature. (4.) Then upon increasing the fire, there will ascend a light yellow fetid oil; and at last, a gross, heavier, and still more fetid kind. (5.) But if the remainder be now calcined in an open fire, and afterwards brought into a lixivium with water, it yields a sea-salt, provided the animal which afforded the urine, took in that kind of salt with its food; otherwise there will not be left, after the operation, the least imaginable portion of fixed salt.

Its physical and medicinal uses.

2. And hence we learn the effect of a considerable degree of heat upon the salts of the human body. The urine distilled, or exhaled away with a gentle fire, affords no alkaline salt at all; but a greater degree thereof gives it an alkaline nature, or causes it to afford an alkaline salt by distillation. And thus we find, when a man has given an uncommon motion to his body, or begins to grow feverish, his urine will smell strong, and appear of a red colour, or like *lixivium*; which shews that the salts and oils thereof are attenuated. But tho it be certain that the salts of the body become alkaline by heat, yet it is hardly possibly they should be so far attenuated, or broken therein, as to appear such in the urine; not only upon account of the languid heat of the body, but because in all probability, as was before observ'd, the tender vessels of the brain, &c. would be destroy'd by the corrosiveness of such salts, and the death of the person effected, before they were rais'd to that degree of acrimony.

PROCESS LXXXV.

Shewing that recent URINE, by being distilled with fixed alkali, is it self turned of an alkaline nature.

The process.

1. **T**O any quantity of recent urine, inspissated in the manner of the precedent process, add an equal proportion of fix'd alkali; and distill them together in a glass retort, with a gentle fire: there will immediately come over first a sharp, volatile, fetid, alkaline spirit, that makes a thorow effervescence with acids; and soon after, a dry, volatile, alkaline, solid salt, which without the addition of the fixed alkali, would have been of the same kind with that of the last process; a saponaceous mass remaining at the bottom of the receiver.

Its physical and medicinal uses.

2. Hence it is easy to imagine, that, besides the peculiar and acknowledged effects of fixed alkaline salts in the human body, they have more-

moreover, the power of immediately rendring our native salts of a sharp alkaline nature, and acting upon them like so much volatile alkaline salt introduced into the body; thereby they turn our half-fixed salts into such as are truly volatile; those that before were of a benign gentle nature, into such as are fiery; those that were neutral and innocent, into such as are corrosive, &c. on which account they act like poison in all such distempers where the salts are too much attenuated; as in acute fevers, inflammatory cases, &c. And hence we may learn *a priori*, what Hippocrates was taught by hazardous experience, to order nothing but acids, or medicines tending to an acid nature, as oxymel, &c. in such kind of distempers.

PROCESS LXXXVI.

Shewing that recent URINE distilled with quick-lime, affords a fiery, yet not alkaline spirit.

1. **W**ITH the rob, or sapa, of recent urine, mix an equal quantity of quick-lime, in a tall glass-vessel, fitted with a receiver, and a violent ebullition, with a great degree of heat, will immediately ensue; and at that very instant there will swiftly fly off from the mixture, and pass over into the receiver, a clear liquor or spirit of an exceeding fiery and pungent taste and odour; yet not of an alkaline nature, or capable of causing an effervescence with acids. The process.

2. This is as volatile, moveable, and corrosive a liquor as any in nature; and if the vessel that contains it be left carelessly stopp'd, tho but for a day or two, it loses all its virtue, and becomes a mere insipid water. It is truly of a fiery nature, being more of a caustic than fix'd alkali it self; so as instantly to eat away the skin, and affect the nerves. Whence we are given to understand the effects of quick-lime, and its lixivium upon the human body; and see that in the twinkling of an eye it can give a strange degree of volatility, and at the same time a most corroding, active, and fiery nature to all the sluggish salts it meets with there. Hence it is evident, that the human salts may have a violent degree of acrimony, or corrosiveness, without giving any signs of an alkaline disposition; as scarce any chemist, besides the excellent Mr. Boyle, has observed; for the spirit of our process will quietly mix with acids, or make no manner of conflict with them; seeming to consist of salts, which by the lime are turn'd entirely into the nature of fire. This makes it not improbable, that the plague is no more than a change of the human salts, into those of an igneous nature; effected by means of certain effluvia floating in the air of pestilential places, and having the power of instantly pervading the human structure, and thus burning up or destroying its vital parts, or faculties. There is one phenomenon which seems to give great countenance to this conjecture; the discolouration and blackness its physical and medicinal uses.

blackness of the skin, which appear as if they were occasioned by the action of some caustic salts. We see, therefore, that in all cases where the salts of the human body are already too much attenuated, or rais'd to a great degree of volatility, this fiery liquor, tho neither acid, nor alkaline, is violently or suddenly pestilential or poisonous; and on the contrary, where all the vital faculties languish, as in apoplectic or lethargic disorders, 'tis a most immediate and powerful remedy; tho it ought to be used with the greatest caution. And hence we are furnish'd with an admirable rule for the medicinal use of the lixivium of quick-lime, or other medicines prepar'd therewith; which can only be proper in cold, phlegmatic, and sluggish or languid constitutions, or dispositions of the blood and juices; and, on the other hand, very pernicious, or even destructive, in thin, hectic and vigorous habits; or such as are subject to the phthisic, &c. because in these cases it sets the salts still more at liberty, and determines them as it were, to a state of putrefaction; to which, by the nature of the distemper, they are already too much inclined. And hence we may learn the cause of that phenomenon which seems to have perplexed the gentlemen of the royal academy of sciences at *Paris*; viz. why the lixivium of quick-lime is so excellent a medicine against the chronical diseases of northern regions; yet very unsuccessfully or fatally prescribed for the same diseases in *France*, *Italy*, and the southern parts of the world. For as the inhabitants of southern regions are naturally lively, brisk and agile, their juices, without question, are very fluid, and consequently their salts attenuated or broke small; so that a lixivium of quick-lime, which produces those very effects in the body, cannot but be prejudicial to them; whereas, in colder climates the human salts are lock'd up in much more viscid fluids, and wanting to be extricated and set free, the lixivium of quick-lime admirably answers this end, and cures the chronic diseases to which the inhabitants of such climates are subject. Thus the scurvy, the principal disease of that kind, is very successfully cured in *Holland* by taking an ounce or two of this lixivium every day, for some continuance. But for the same reason it ought never to be given in bilious and sanguine habits. For the effect of it, we see, does not depend so much upon the lime it self, as it does upon the humours it shall happen to meet with in the body, and the manner wherein it mixes with, and prevails over them, as *Helmont* judiciously remarked.

PRO.

PROCESS LXXXVII.

Shewing, that recent URINE will crystallize by inspissation, or afford an essential salt.

1. **E** Vapourate a large quantity of the recent urine of a healthy man, to the The process. consistence of a syrup, with one continued degree of heat; separate the oil from it by the filtre, and afterwards put it into a close vessel, and set it in a cool cellar, for the space of one year; it will shoot into a thick, brown, saline glebe, or crust, at the distance of an inch or two from the bottom of the vessel: then carefully pour off all the liquor that floats above, take out the mass of saline crystals, and lay the matter at the bottom thereof aside for phosphorous. These crystals, which are of a peculiar nature, being dissolv'd in pure warm water, filtred and evaporated to a pellicle, and set again to shoot in the cold, will again run into crystals sui generis, or a white purified salt, of a nature different from all other salts, and become the purer, the oftener the process is repeated; so that it may justly be call'd the essential salt of urine, or of the human body.

2. It may indeed be objected, that this salt is not obtain'd, but by The nature of the production. suffering the urine to putrefy; which is true: nor is there any other way yet known of procuring it. Neither will the addition of oil of vitriol, or any other acid, prevent its putrefaction; so strongly is it inclin'd thereto. It cannot however be said, that this is the common, or sea-salt, which will evidently appear upon the comparison; this being totally volatile at the fire; whereas sea-salt remains fix'd in the strongest heat. Neither hath it the properties of borax, nitre, sal-gem, sal-armoniack, &c. but is really a salt sui generis, and not to be match'd by any other salt in nature. The process for making it is indeed tedious and laborious; and it cost me no small pains to discover in what manner the salts did really exist in the human body. To do it with the greater advantage, I have evaporated more than two hundred weight of recent urine, and treated it in the method already deliver'd; by which means I came to a knowledge of the essential salt of the human body; and upon trial find that it is of a wonderful diuretic and emmenagogic virtue, yet without any sharpness at all, being neither alkaline nor acid. This salt cannot be so easily obtain'd from the blood or bile, by reason of their grossness, tenacity, and the large quantity of oil wherewith they abound; but readily enough from urine, which is as it were, the lixivium of the blood.

PROCESS LXXXVIII.

Shewing, that recent URINE becomes alkaline by digestion.

The process.

1. **S**ET any quantity of recent urine, obtain'd with the conditions formerly mention'd, to digest in a tall glass, with a heat no greater than that of a healthy man, for the space of three or four days, and it will continually grow more and more red, fetid, cadaverous and alkaline; throwing off a stony matter to the sides of the vessel.

Its physical use.

2. The experiment will succeed in the same manner without the assistance of heat, by letting the urine stand in a well-closed vessel for five or six weeks in the cold; but a gentle heat will greatly shorten the process. The urine thus digested has a fiery lixivious taste, and will make an ebullition upon mixing with acids; whereby it may in a manner be reduced to its recent state again. Being of this nature, it is of singular use, as a lixivium, to dyers, and the scourers of cloth, in order to cleanse their wool, or prepare their stuffs to receive the dye; for there is always a greasy matter sticking to wool, whether manufactur'd or unwrought, which hinders the striking of the colour, unless it be first wash'd away with a proper dissolvent; such as the lixivium of quicklime, pot-ashes, or the like; which coming too dear, digested or putrefy'd urine is commonly employ'd in their stead, for the purposes above-mention'd.

Its medicinal uses.

3. This process may serve to point out to us several useful particulars relating to the practice of physic; and particularly, 'tis highly serviceable in ascertaining the diagnostics of diseases. We learn from it, that if the urine be too long detain'd in the bladder, it will acquire a corrosive, alkaline nature, destructive to the body, and capable of changing the colours of other substances, as we see when catheters are thrust into the bladder, in case of a long suppression of urine; and the like change will the other fluids receive, by stagnating for any considerable time, which may give rise to various diseases. Thus for example, when a person is first seized with the dropsy, he is not at all affected either with a thirst, or fever; but after the collected water has remained stagnant for a small time in the cavity of the abdomen, it presently causes a drought, heat, fever, &c. all which symptoms proceed from the acrimony of the fluids, acquired by digesting, as it were, in the abdomen; for upon this, the salts and oils of those juices become so sharp, as to corrode the vessels of the body, and greatly disturb the whole animal frame. On the same account it is, that the putrefaction of the body ensues so suddenly after death; tho it might, if the fluids had still remained in their circular motion, have continued much longer uncorrupted. Hence we learn, that the bare want of motion in the animal fluids may cause violent disorders, by thus rendring the salts and oils more volatile,

active

active, and powerful, or setting their parts free, and leaving them to themselves. Hence stony matter may readily be generated by a bare detention of the urine in the bladder, as in our present process it is thrown to the sides of the containing vessel. And this will happen in the urine of any man, tho not at all troubled with the stone or gravel; the solution or cure whereof it is, therefore, in vain to expect from putrefaction. This separation of the parts of the urine, or acquired alkaline nature, and not its bare quantity, appears to procure the death of the patient in long suppressions of this excrementitious fluid; the effluvia, or fiery alkaline spirit whereof, now, after having stagnated for some days, gets to the brain, and destroys its tender substance. And thus we have seen three ways wherein the salts of our bodies may be rendered volatile, viz. by heat, the admixture of alkaline salts, and by their bare stagnation.

P R O C E S S LXXXIX.

Exhibiting the resolution of digested URINE into an alkaline spirit, an alkaline salt, two kinds of oil, phosphorus, earth, and sea-salt.

TAKE urine digested after the manner of the preceding process, and The process. distill it in a tall glass retort with a gentle fire. The first thing that will come over, is, (1.) A clear fetid liquor, rich in volatile salt, of a fiery acrimony, capable of making a strong effervescence with acids, and consequently of an alkaline nature. (2.) A yellow, volatile, fetid alkaline salt, that appears in a dry form. And if now the remainder be exhale to the consistence of a sapa or thin honey, then mixed with four times its weight of dry sand, and the distillation be continued in a coated retort, with degrees of fire, there will come over, (3.) A large quantity of a very fetid, brown oil, impregnated with salt, and at length one of a gold-colour; then the retort being taken away, and a much larger substituted, half full of water, and the fire increased to its highest degree, (4.) Blue fumes will ascend, which, in the dark, appear like flame in the vessel. And (5.) With a violent heat there will distil over a gross, shining matter, that sinks to the bottom of the water, and called by the name of solid phosphorus: and here the operation ceases, nothing but an earthy substance remaining behind; which, being boiled in water, cleansed with lixivium, and again dried and calcined, affords a quantity of sea-salt, but none at all that can be called fixed alkali.

2. The process must be stopped after the volatile salt is come over, Directions for managing and improving it. and sand, powdered bricks, or the like, be mixed with the sapa; otherwise it would swell, and come over all at once in the distillation. The gross matter which ascends the last in this operation, will not dissolve in the water wherein it falls; but may, by inclination, be separated from it; and then being exposed to a gentle heat, it will melt like

like wax, and remain capable of being formed into glebes, or pieces of any size, which are to be kept continually under water; by which means it may be entirely kept from consuming, for many years. And this is the solid phosphorus, which spontaneously takes fire, and shines when brought into the open air. It will never fail to do this, provided the operation is managed with care; but it requires the constant attendance of the operator for four and twenty hours, to see that all the parts are conducted as they ought to be. But to make this phosphorus more directly, and to the best advantage, it may be proper to take a sufficient quantity of human urine, afforded by a person not much given to drink wine, and exhale it away in an open vessel to a rob, or the consistence of honey; then set it to putrefy for half a year, and upon distillation it will afford a large proportion of salt; after which, if six times its own quantity of sand or brick-dust be added to the remainder, and the distillation be continued as our present process directs, the phosphorus will fall into the water as there mentioned. Or, it may commodiously be prepared in the manner of the *eighty seventh process*, by suffering the rob of urine to digest for two years in an open vessel in the open air; during which time a slimy, fæulent, unctuous, earthy matter will be let fall to the bottom; which being frequently washed with pure water, wherein it will not dissolve, it will leave a white matter behind it, neither of an alkaline, acid, saline, or terrestrial, and scarce of an unctuous nature: and this is of it self a proper matter for the making of phosphorus by distillation with sand. A thick crust of saline matter, shot into crystals, grows, as we formerly said, upon this fæulent substance; which being cautiously separated, and well washed with pure water from the matter of the phosphorus, gives the essential salt of the human body. Then all that matter which floated above this salt, being mixed with thrice its quantity of sand, and carefully distilled in a close vessel, with a gentle fire, to dryness; there will first come over a volatile spirit, then a salt; which, according to *Helmont*, is wonderfully appetitive: and now, the receiver being changed, there will arise a large quantity of a crystalline salt, of an alkaline nature, and stick to the sides of the glasses: and this salt, by one rectification, becomes so volatile, that it can scarce be contained in any vessel, tho' ever so closely stopped. And if the spirit be rectified, and kept in a pure glass vessel, it will deposite a large proportion of a brown stony earth; which is by *Helmont* taken for the matter of the stone in the bladder. The fire being now much increased, a brown and very fetid oil will come over; and at length one of a fine yellow colour, which, when rectified with the spirit, *Helmont* takes for the dissolvent of the human calculus. And now the remaining matter being urged with the strongest naked fire, in a coated retort, and a very large receiver, half full of water, employ'd, the phosphorus it self will at last come over. It is surprizing how long this phosphorus will continue shining, at an incon-

siderable

considerable expence of its substance *. And besides this, there are many strange phenomena observ'd of it; as particularly that of its perpetual flashing or shining on the hot nights of the summer-season, according to what is delivered of it in the philosophical transactions of London. Here again, if the *caput mortuum* be dissolved in water, filtered, evaporated, and calcined, it will afford a quantity of sea-salt; which gave occasion to *M. Viussens*, and *M. Homberg*, to suppose there was an acid salt contained in the human body. That this is really sea-salt, is manifest by the proper experiments, which shew it to have all the characters thereof. In taste and smell it plainly appears to be such; and when added to *aqua regia* will cause it to dissolve gold. 'Tis true, however, that it cannot be made to crystallize so readily as sea-salt; but this proceeds from the oil with which it is intimately united in the body: for it is a known thing in chemistry, that the mixture of any thing unctuous prevents the crystallization of salts. We see then, and may be certain, that sea-salt passes unaltered thro' all the conduits and strainers, all the digestions and circulations of the body, whose vital powers are insufficient to destroy its texture, or change its nature; which is more than even putrefaction it self, or a violent degree of heat, can effect; as plainly appears from the present process. The antient adepts, therefore, were well aware what they did in saying, gold and sea-salt are the most perfect, or indestructible bodies in nature, as passing thro' others without alteration; and accordingly other salts, as tartar, nitre, &c. may readily be changed into alkalies; whilst this constantly remains in full possession of its native virtues. Its use, therefore, seems to be to preserve the bodies thro' which it passes from corruption; and particularly the human: it deterges its vessels, keeps the fluids from running into putrefaction, and prevents the formation of stony matter. Whence we learn the reason why the antients gave sal-gem in putrid fevers; and how a mixture of sea-salt and sulphur came to be such a favourite medicine with *Hippocrates* in pestilential cases, or where the juices of the body tended to corruption. *Helmont*, also, successfully employ'd the same salt, with vinegar and sulphur, in the plague. But all manner of vegetable salts are entirely changed, or lose their own nature in the human body, and put on that of a volatile alkali. If an animal were to take in no sea-salt, a thousand pound weight of his urine would not afford a single grain of any acid or fixed salt; whatever were the food he made use of. *M. Viussens*, indeed, has wrote a very large treatise to shew that an acid salt may be obtained from animals; but the acid he means is no other than the spirit of this sea-salt, contained in the urine, and raised by a strong fire. And that a strong acid spirit may be gained in this manner from it,

* Mr. Boyle has many curious observations relating to this subject, in his surprizing little piece called *Aerial Noctulica*.

we shall see hereafter. *M. Homberg*, likewise, fell into the same error, in imagining he obtained an acid salt from human blood, by distilling it with its own dry *caput mortuum*. The fallacy of which experiment is manifest from hence, that the blood of any other animal that makes no use of sea-salt will not afford this acid. We, therefore, boldly assert, that there is neither acid, nor fixed alkaline salt, naturally contained in the bodies of any animals whatsoever; which must therefore be endued with the power of converting all kinds of salt, except sea-salt, into such as are of a volatile alkaline nature, or capable of being easily made so.

Its use in medicine.

3. It appears not improbable from what is here laid down, that the matter of the stone in the bladder may reside in the spirit of putrefied urine; which, tho clear at first, is yet full of salt, and by degrees changes to a yellow colour, shoots into crystals, and lets fall a red terrestrial substance, very like gravel, or the matter of the human *calculus*; which will again be taken up by the spirit upon a fresh rectification. Whence it may be conjectured, that a dissolvent for the stone is really contained in the urine it self, which forms it. And doubtless the matter of the stone was once a part of the urine; and perhaps of its salts, which appear rather to generate than dissolve the stone in the bladder. Sea-salt, without dispute, will in a great measure prevent the generation thereof; but not absolutely preserve the body from it, as *Helmont* imagined. If urine be mixed with sea-salt, nitre, vitriol, &c. the several parcels will, in time, deposite a stony matter; but that the least, to which the sea-salt was added. From whence it should seem, that if any salt could prevent the generation of the stone, it would be marine salt.

CHEMICAL HISTORY of SAL-AMMONIAC; a Preparation from URINE.

PROCESS XC.

Exhibiting the production of SAL-AMMONIAC, by digesting and boiling Urine with sea-salt and soot.

The process.

1. **T**O ten parts of the urine of any sound animal that drinks but little, discharged at the distance of twenty hours from feeding, add two parts of sea-salt, and one of wood-soot; digest them together for a considerable time in a warm place; and afterwards gently distil the mixture in a glass retort, with a sand heat, till the remaining mass becomes almost dry; diminishing the fire towards the end of the operation, to keep the matter from subliming: then take

take out the remaining mass, beat it to powder, and sublime it in large vessels, with proper degrees of heat, into gleses, or lumps, which are called by the name of common sal-ammoniac.

2. This is the common method of preparing sal-ammoniac, as practised in Europe, and particularly at Venice, as also in many parts of Asia, as Alexandria, Cairo, &c. where it is made in a large quantity, and to great advantage, because they there have plenty of animals, and particularly camels, which drink but very little; tho the same end may, in good measure, be answered by a longer digestion; wherein the urine acquires an alkaline nature, and the sea-salt is attenuated and grows acid; which thus form themselves into a third kind of compound salt, that in effect is sea-salt volatilized. In this process we are therefore to take the urine, which is the basis, for an alkali, and the acid of the sea-salt for the fixer, whereby a new semi-volatile, neutral salt is at length composed. The soot is added only on account of the copious, volatile, acid, or alkaline salt it contains; as we formerly saw in our processes upon vegetables, particularly those performed on *lignum vite*, and mustard-seed.

3. There are reckoned two kinds of sal-ammoniac, the natural and artificial. The artificial is that already described; and *Diascorides* gives us an account of the natural, which is found in *Lybia Cyrenaica*, near *Egypt*, in the place where the temple was built to *Jupiter Ammon*; from whence it is called *Sal Ammoniacus*, and by *Diascorides*, *Sal Cyrenaicus*. This temple was formerly very much frequented by strangers of all countries; who rode thither upon camels, a kind of animal remarkable for their long enduring of thirst. The truth is, they are wonderfully formed for making very long journies, without stopping to drink by the way; as being naturally provided of three or four receptacles near the stomach, with each its proper sphincter, in which they reserve part of the water they take down at once, to be ready, as their occasions, in passing over sandy deserts, shall require: for by this contrivance they have always something in readiness just to moisten their mouths withal; and as their drivers encourage this action in them, by rubbing their mouths with sea-salt three or four times in the day, they can very well pass three or four days without drinking. When thus, after a tedious journey, without any other opportunity of coming at water, these animals arrived at the temple; their urine, which they there plentifully discharged in the sand, being already, as it were, digested by the heat of their bodies, was farther concocted by the rays of the sun, and made to shoot into saline gleses, or lumps; which being afterwards found in this place by future pilgrims, they called it *sal-ammoniac*. So that in reality, this is not a native, as it has been supposed, but rather an artificial salt, prepared much after the manner of our present process. And this account of the thing is fully confirmed from hence, that the like salt is found in stables or stalls of camels; but not at all near the spot where the famous temple stood, since it has ceased to be so much frequented

Processes upon Animals.

quoted on religious accounts. But how it should happen that sal-ammoniac is at this day likewise found near vulcano's, or burning mountains, such as *Ætna* and *Vesuvius*, after their eruption, is not so easy to say. This is certain, that upon examination, the salt found in such places, and sometimes under-ground, appears to be entirely of the same nature with that of our present process.

Medicinal uses
of the prepara-
tion.

4. Sal-ammoniac, by being dissolved in water, boiled, skimmed, filtered, evaporated to a pellicle, and set to shoot in large vessels, will be converted into a pure white salt*, of a most subtile, penetrating, and stimulating nature, capable of passing thro' all the viscera and canals of the body, the nerves alone excepted; and powerfully resisting putrefaction in the body. This salt wonderfully mixes with the animal fluids, and becomes apperitive, sudorific, and perspirative: on which account it is famed for an admirable febrifuge; and being given before the fit, in the quantity of a dram, or four scruples, for a dose, dissolved in water or wine, it surprizingly cures quartan agues, in such constitutions as are free from scirrhoties, and a hectic; otherwise it commonly increases the distemper. Indeed it is an excellent medicine both in acute and chronical diseases; being a benign salt, much gentler in its operation than fossil salts, and nearly of kin to that of our own bodies; but not tending at all to an alkaline nature, and moderately dissolving the blood. *Galen* has well observed of it, that, being of a less specific gravity than sea-salt, it dilutes the blood without raising any violent commotions therein; for which reason it may be exhibited to greater advantage in many diseases, where the body cannot bear to be disturbed. Whilst it dissolves in water, it gives an intense degree of cold thereto, and little inferior to that of ice itself: so that any liquors plunged in the solution, may be rendered extreme cool, and potable with pleasure, in the violent heat of summer.

PROCESS XCI.

Shewing that SAL-AMMONIAC is neither acid nor alkaline.

The process.

1. **T**O a quantity of sal-ammoniac dissolved in fair water, pour any strong acid liquor, and no signs of effervescence will appear. Then to another parcel of the same solution, add the strongest alkali, whether fixed or volatile, and still there will no motion or ebullition be made; but the salt, which before was scentless, will now in an instant exhale a sharp, volatile, alkaline, caustic vapor, like that of putrefied urine.

Its use.

2. It is somewhat strange in this experiment, that the sal-ammoniac, tho composed both of alkaline and acid parts, should afford no signs of either. Urine, left to it self, we know would putrefy; but when formed into this kind of salt, it neither putrefies nor appears so much

* This is the common method of purifying sal-ammoniac.

as alkaline; which is an instance of the virtue that sea-salt has of preserving the animal fluids from corruption.

P R O C E S S X C I I.

Shewing the method of purifying SAL-AMMONIAC by sublimation; in which the flowers turn neither alkaline nor acid, but still retain the nature of that salt.

1. **G**RIND a proper quantity of well dried sal-ammoniac to fine powder, *The process.*
 put it into a low cucurbit, with a wide mouth, and lute on a suitable head, in the common manner: bury the glass in a sand-furnace, almost up to the head; and gradually increase the heat to the highest that can be given in sand, and all the salt will rise in white fumes, and fix it self, like snow, in a white glebe, to the sides of the head, except a small quantity of grey or blackish feculent matter, that remains at the bottom of the cucurbit; by which means the salt will receive no manner of change in its nature, as to acid or alkali, but only be made more pure and penetrative.

2. Hence we see that sal-ammoniac is of a nature between fixed *Its uses.*
 and volatile; being almost totally sublimable by a strong heat, tho not capable of being raised by a small one. And 'tis very remarkable, that in this process it is not analyzed, nor suffers any division of its parts; but rises again entire into salt, without affording any oil or spirit, or becoming of an alkaline nature. And this last property is what alone distinguishes it from the genuine animal salts, which constantly turn alkaline by the action of the fire; whereas, tho sal-ammoniac were sublimed a thousand times over, it would gradually become more pure and penetrative indeed, yet never of an alkaline nature; but, notwithstanding its being totally volatile or sublimable, remain the same unchanged sal-ammoniac it was at first. And this has occasioned the chemists to call it *Aquila alba*, the white eagle, in allusion to the bird which carried *Ganymede* up to *Jove*; its wings, to speak in their language, that is its particles, which rise in sublimation, carrying up the particles of any other bodies, and even such as are metalline, mixed along with it. 'Tis likewise termed the hand or pestle of the chemists; because it subtilizes, or grinds, the parts of the bodies sublimed therewith; as appears evidently in *Lapis Hematites*, which is ground exceeding fine, or reduced to flowers, by undergoing this operation along with it. And if even gold, the calx of vitriol, tho ever so long calcined, or the most fixed bodies in nature, be ground with this salt, it will presently render them volatile in the fire, and make them sublime; and hath this good quality belonging to it, that, being neither acid nor alkaline, it may easily be separated or washed away from any of those bodies that are sublimed along with it. The character whereby the chemists generally denote it, is such as exactly expresses the figure of its crystals, thus *.

C c

P R O-

Processes upon Animals.

P R O C E S S X C I I I .

Exhibiting the manner of obtaining a most fiery, volatile and penetrating Spirit from SAL-AMMONIAC mixed with quick-lime.

The process.

1. **T**AKE equal parts of the flowers of sal-ammoniac, the production of the preceding process, and good stone quick-lime; and in a dry mortar, and dry air, speedily grind them separate to fine powder, then presently mix them together; and at that instant the most fiery, volatile, caustic, and piercing vapour hitherto known will fly off from the mixture; being exceedingly like to that which rises from the mixture of inspissated urine and quick-lime. (2.) If this mixture be directly distill'd, with a proper addition of water, in a well luted retort and receiver, by slow degrees of fire, it will yield a wonderfully sharp and volatile liquor, which, tho violently caustic, is scarce at all of an alkaline nature. (3.) The remainder, after distillation, being put into a crucible, and detained in an open fire till it melts, may afterwards be run into glebes, and preserved as a kind of phosphorus; for it will shine in the dark, and afford sparks of fire by percussion. But it must be kept from the air, to make it continue fit to afford this phenomenon.

Use of the production.

2. The subtle spirit, obtained by this process, proves violently pungent and stimulating to the nerves; for which reason it is very useful in all lethargic, apoplectic, or epileptic cases, or where the spirits are to be suddenly roused or recalled; but it is always to be employed with the greatest caution; for if a person, not affected in this manner, were to draw the vapour of this spirit at his nostrils, it would instantly strike him to the ground, like thunder; and either suffocate him, or by seizing upon and corroding the tender membrane, or vessels of the lungs, suddenly cause a peripneumonia, or else an inveterate cough for life.

P R O C E S S X C I V .

Shewing that a fiery Spirit, and a volatile alkaline Salt are obtainable from SAL-AMMONIAC by means of fixed alkali.

The process.

EXpeditionfly grind equal parts of the flowers of sal-ammoniac, and fixed alkali, or salt of tartar, separately, to fine powder, in close vessels, without admitting any moisture to come at them; afterwards mix them speedily together; and from these two scentless bodies there will immediately arise a fiery, volatile, caustic, alkaline, and strongly odorous vapour, like that which arose from the mixture of inspissated urine and fixed alkali; and may, after the same

same manner; be caught, and condensed into a liquor by proper vessels. (2.) The mixture being put into a cucurbit, and distilled very carefully and artificially, with a large and well luted receiver, in a sand-heat, there will ascend a dry, white, or wonderfully volatile salt, in appearance like to the flowers of sal-ammoniac, but violently caustic and alkaline. (3.) If a quantity of water, equal to that of the sal-ammoniac, be added to the mixture, and the process carried on as above-mentioned, there will arise a dry, volatile salt; which, as the operation is continued, will, tho it be a pure salt, without earth, oil, or acid, be dissolved down in veins, like oil, by the subsequent phlegm, into a liquor commonly called alkaline spirit of sal-ammoniac.

2. The salt obtained in this process, is so exceedingly volatile and penetrative, that it is scarce possible to keep it in a glass, tho ever so closely stopped with cork and bladder; nothing but a glass stopple being able to withstand it. It will every grain exhale insensibly away thro' the least imaginable crack or vent; or, if the air gets at it, immediately melt in the vessel. It is so violent a caustic, that if applied to the skin, and covered with a bladder to prevent its being suddenly exhaled by the heat of the body, it will, in the space of a minute, eat into and mortify the part. If, upon occasion, it be desired still stronger, it may be made entirely of an igneous and perfectly caustic nature, by subliming it once or twice with fresh salt of tartar; by which means it may be made so strong, as instantly to destroy a man by its scent: for its vapour thus seems perfectly to condense or squeeze the lungs together, so as to hinder their expansion, and render their recovery difficult even by the use of the strongest spirit of vinegar. And for this reason, its vapor is to be very cautiously avoided in the preparation. Use of the preparation.

P R O C E S S XCV.

Exhibiting the preparation of Sylvius's Febrifuge Salt, from the remains of the preceding process; or the regeneration of Sea-Salt from SAL-AMMONIAC.

1. **W**HEN all that is volatile in the subject of the preceding process, has been driven over by the violence of the sand-heat, a dry mass of a fixed salt will remain at the bottom of the glass; which being put into a crucible, fused in an open fire, dissolved in water, filtered, evaporated to a pellicle, and set in a cool cellar to shoot, will afford crystals of a cubical figure, having the pungent taste, fixedness, and colour of sea-salt, as also the power of dissolving gold, when mixed with Aqua fortis or spirit of nitre; that is, crystals of genuine sea-salt. The process.

2. The sea-salt thus regenerated, is called by the name of Sylvius's Febrifuge salt, because he is said to have used it, as a secret, with great success in the cure of intermitting fevers; and for that purpose, preferred it to all other salts. His method was to give it in the quantity Sylvius's Medicinal use of the production.

tity of fifteen or twenty grains for a dose, dissolved in carduus-water, two hours before the time of the fit, in order to prevent it by sweat, or to break away the febrile coagulum in the blood. But however he might esteem it, 'tis certain that sal-ammoniac, or its flowers, are a much better medicine to answer the same end: nor do I know a more effectual remedy than about twenty grains thereof, given in a draught of hot wine, or other convenient warm liquor, an hour or two before the fit is expected, for the cure of tertian and quartan agues. A single dose will commonly put by the former, and three or four will finish the cure of the latter; provided the patient be not of a cachectic habit of body. This is likewise a more valuable and certain medicine than that powder which has been sold at a high price for a febrifuge, consisting of *antimonium diaphoreticum*, and the regenerated sea-salt of our present process.

Physical and
chemical uses
of the process.

3. We learn from the preceding processes, that sal-ammoniac consists of a volatile, animal alkali, fixed by the volatile acid of sea-salt. But as fixed alkali attracts acid more strongly than it does volatile alkali, if fixed alkali be mixed with sal-ammoniac, it will draw to it self the acid of the sea-salt, from the weaker animal alkali; which being then deprived of its fixing acid, will be left purely urinous and volatile. Upon this, all that is volatile being driven away, it is evident that the fixed alkali, now saturated with the acid, must remain behind, possessed of the fixedness and other properties of sea-salt; that is, the sea-salt of the composition will be regenerated: and thus the spirit of sea-salt, and the spirit of urine mixed together, in such a proportion that each shall be saturated with the other, will constantly make a sal-ammoniac. Whence we are taught the nature and origin of volatile alkaline salt; the method of producing it; of fixing it when produced; and again of setting it free and making it volatile. Upon the whole, it appears, that there is a very great similitude between sal-ammoniac and the salts of the human body; the principal difference being only this, that the latter readily turn of an alkaline nature, by the first impression of the fire; whilst the other, as was before observed, obstinately remains the same, after repeated sublimations; both of them in other respects, as particularly in distillation with fixed alkalies, &c. exhibiting the like phenomena.

CHEMICAL HISTORY of the WHITE of EGGS.

THAT we might have a just chemical history of the animal kingdom, Introduction to the history of the white of eggs. it was necessary first to examine that fluid which begins to receive an animal nature, without having perfectly attained thereto; and this, we saw was milk. In the next place, we were to make our experiments upon that animal liquor, which, by having undergone repeated circulations in the body, was arriv'd at a perfect animal state; but which, if long detain'd in the body, would become noxious, or prejudicial thereto. It is now in the third place, incumbent on us, to inquire into the nature of those juices which are not only most completely animal, but so wholesom, as that they may safely be detain'd in the body, and constitute the parts thereof, without prejudice to any of the faculties, whether animal, vital or natural: and this is an inquiry of singular service to let us into the knowledge of animal nature. We are, therefore, next to find, for the object of our succeeding experiments, such a perfect animal fluid as is no way excrementitious, but may be separately collected without any heterogeneous parts, and certainly known to afford the matter for the formation of all the parts of animal bodies, both liquid and solid. And this fluid we have from the oviparous class; it being no other than the white, or pellucid part of the egg wherein the yolk appears to swim. All the parts of a chick, as the blood, flesh, bones, &c. are form'd out of the bare white of the egg; for nothing but this is consumed during the time of the incubation of the hen: the yolk all the while remaining entire, and serving as the *placenta*, which appears to be vascular, or to consist of a number of vessels, to prepare the white, and make it a fit nutriment for the body of the chick. It is, therefore, an elaborate, and absolutely finish'd liquor, wonderfully design'd by nature to compose all the different organs of the oviparous tribe of animals: so that in order chemically to discover the nature of animal bodies, we cannot have a more proper subject for our experiments than this liquor, which is wholly convertible into their substance, except that single point, or speck thereof, which proceeding from the male, lays the first rudiments of the foetus, and without which no young is ever excluded. By the examination of our senses, the white of eggs appears to be a viscous, mild, unactive, insipid, inodorous liquor, capable of mixing with water; but incapable of causing pain to any part of the body, even the eye it self.

Processes upon Animals.

PROCESS XCVI.

Shewing that the WHITE of EGGS is neither alkaline nor acid.

The process.

1. **L**ET fall any proportion of a known acid, as oil of vitriol, &c. tho ever so strong, upon the white of an egg, contain'd in a proper glass, and it will cause no effervescence or ebullition therewith; and consequently, it is no alkali. Upon another parcel of the white, let fall any quantity of a known alkali, as oil of tartar per deliquium, and this likewise will cause no ebullition; consequently the white is not an acid. Nor will it manifest any signs of either, by the other known experiments allowed to distinguish acids and alkalies.

Its effects.

2. The oil of vitriol indeed will cause the white of the egg to appear of a somewhat thicker consistence than it did before; and the same will happen in the blood and its serum; tho without the least effervescence. But if these animal fluids were either acid or alkaline, so far as, by the mixture of their opposites, to cause such an ebullition in animals, as would, for instance, be made by mixing two different parcels of the liquors of our present process together, their bodies would be burst to pieces with the force.

PROCESS XCVII.

Shewing that the recent WHITE of EGGS dissolves with a gentle heat, but concretes with a stronger.

The process.

1. **P**LACE the white of a new-laid egg in a very gentle heat, scarce exceeding that of a healthy human body, and it will gradually grow thinner and thinner, till at length it totally liquifies, and becomes almost like urine. (2.) Expose the white of another fresh egg to twice the former heat, or one equal to that of boiling water, and it will immediately, without any considerable exhalation, be hardened or concremented into a white, opaque, dry, viscous, fissil mass, inodorous, insipid, and not without difficulty to be resolv'd again.

Its use in natural philosophy.

(2.) When a hen sits upon an egg incapable of affording a chick, the heat of her body, which is much the same with that here first made use of, gradually liquifies the internal part thereof, and turns it to a fluor, which at length becomes of a putrid nature, like digested urine; whilst, on the other hand, the same degree of heat, gradually dissolves down the white of a prolific egg into fit nourishment for the chick. But if the heat were considerably greater, we see by our present process, that this effect would not be produced; for the white would then be concremented, and become incapable of nourishing the embryo. And that this alteration in the consistence of the white of the egg cannot be owing to any evaporation of its humid parts, is plain from hence, that the same thing would immediately happen,

pen, if the egg were plunged entire, with its shell, or only the white, into boiling water; and this is likewise the case of the serum of the blood, and other juices of the human body.

3. Here we are taught, that there is a surprizing difference, as to the effect, between the action of different degrees of heat, upon the same animal liquor; and no less than that of fluidity and firmness: whence it is easy to account for the good effects produced by the application of warm cataplasms, or fomentations in tumors and other cases of chirurgery; and for their bad ones, when they are apply'd too hot to the part. Warm fomentations may discuss and resolve the concreted or coagulated juices; but such as are scalding hot, may easily confirm the tumor, or, if seated in a glandulous part, turn it schirrous; that is, into a substance that will not easily putrefy or dissolve. Water that is made a little hotter than the blood of persons in a fever, will soon thicken the serum and other animal fluids, and make them concrete. And it is certain, that a violent degree of heat is very pernicious to the human body; as occasioning grievous obstructions or polypus's therein. And of this we have daily instances in the blood of those who labour under any inflammatory, or hot distemper: so that their opinion is the direct contrary to truth, who assert, as some physicians do, that heat, in general, resolves and attenuates the animal juices; whereas any considerable degree thereof will certainly thicken, and make them viscid. And thus, tho it be generally supposed that hot water dilutes and thins the animal fluids; yet, if it be drank more than blood-warm, the truth of the assertion may justly be questioned.

P R O C E S S XCVIII.

Shewing that the recent WHITE of EGGS is concrescible in alcohol.

1. **P**UT the crude and liquid white of a new-laid egg into a quantity of pure ^{The process.} alcohol of wine, in the cold, and it will immediately concrete, or coagulate, as by the heat of the fire, or boiling water; the coagulation of the parts proving the stronger, the more intimately the alcohol is mixed with the white: and thus it may long be preserved in a state of incorruption.

2. Here we learn the natural effects of a fine, vegetable oil, upon the ^{its medicinal use.} matter whereof all the parts of an animal body may be form'd; whence we may see, how it comes to pass, that spirit of wine is such an immediate styptic, and anodyne, as we find it in case of hæmorrhages, and punctured nerves; why pure wine used by way of fomentation has the power of discussing tumors, whereas pure alcohol would make them schirrous; why alcohol injected into the veins is sudden death; and whence it happens, that being drank, it is observed by medicinal writers to have been of the nature of poison, and proved speedily mortal. For thus it coagulates the blood and other animal juices, and instantly causes obstructions.

Processes upon Animals.

obstructions in the vessels of the body. Those physicians then are greatly mistaken, who take pure alcohol for an attenuating and resolving liquor, that volatilizes all the animal fluids, and renders them the more perspirable. On the contrary, it is frequently found to harden and condense them, as appears particularly in the case of swell'd and indurated breasts; which being fomented with spirit of wine, or *Hungary water*, in hopes of resolving the tumor, thereby become more hard, and cancerous.

P R O C E S S X C I X.

Shewing that the water gained from the WHITE of recent EGGS, by gentle distillation, is neither acid, nor alkaline.

The process.

1. **B**Oil a sufficient quantity of the white of fresh-laid eggs, in water, to a hard consistence; then commit it to a retort, placed in *balneo mariae*: gently distil it till it becomes almost dry; and there will come over a very large proportion of a volatile water, that has scarce any scent or taste, unless it inclines a little to fetid and sulphureous; and neither of an inflammable or spirituous, an acid, or an alkaline nature, as will appear upon the proper trials.

Confirmed; with its use.

2. If the white of eggs, after it is boiled, be suffered to remain for any considerable time, even in the open air, without heat, it will distil, or again resolve as it were, and suffer a very great diminution in its quantity, so as at length to appear in the form of a thin pellicle, almost like paper; and if the water be collected in proper vessels, it becomes an admirable solvent for bodies otherwise very hard to dissolve; so that even gum-hedera, or the like substances, are by means thereof easily reduced to an oil. Hence it is manifest, that the salt, spirit, and oil are more fixed in the white of eggs, than the phlegm or water; which appearing upon examination to contain no latent alkaline, or acid salt, we may fairly conclude, that the fluid whereof all the parts of an animal body may be composed, has naturally nothing in it that can be called of an alkaline or acid nature.

P R O C E S S C.

Shewing that the WHITE of EGGS, by a strong distillation, affords an alkaline spirit, and salt, two kinds of oil, and an earth.

The process.

1. **I**F the remains of the preceding process be urged with proper degrees of fire in a sand-furnace, there will first arise a yellowish spirit, which by rectification affords a large proportion of dry, white, volatile, alkaline salt. Upon
increa-

increasing the heat, there will ascend a copious, alkaline salt, together with a light, fetid, gold-coloured oil; and lastly, with a violent heat, one that is gross, thick, black, and strongly fetid; a light, black, spongy earth remaining at the bottom of the retort, and, by calcination, in an open fire, affording no fixed salt, but becoming white and inspid; tho it can never, by any art, be perfectly freed from its oil.

2. Hence we learn what surprizing alterations different degrees of *Its use.* heat can bring upon the subject matter of animals; and may conclude, that volatile salts never, in their own form, naturally exist in animal bodies, whilst they enjoy a state of health; and that the heat required to render them volatile would first destroy the body.

P R O C E S S C I.

Shewing that the WHITE of EGGS will putrefy by digestion, and turn alkaline.

1. **P**UT a quantity of the white of recent eggs into a tall glass, and, with *The process.* a gentle heat, not exceeding that of a healthy man, digest it for a few days, and it will gradually become more fluid and transparent, and afterwards begin to smell fetid and alkaline, till, at length, it will not coagulate at the fire, but make an effervescence with acids, exactly like putrefied urine; and if it be now distilled, it first affords an alkaline, volatile, spirit, instead of the inspid water it would yield before digestion; and if the operation be continued, it will proceed in every respect as the distillation of digested urine.

2. A single grain, or even half that quantity of this putrefied sub-*Its use.* stance, being taken into the body, will, like the strongest poison, presently cause a violent nausea, vomiting, and eructations, a fever, a diarrhoea, &c. as Bellini tells us he has tried. And I my self have more than once seen it given, without the knowledge of the person who took it; and then also it has had these terrible effects: which, however, are immediately stopped by drinking any acid liquor, as vinegar, the juice of lemons, &c. Even the scent thereof may, by a longer digestion, be made to do the same. Having once continued the operation for the space of eight days, and then coming to handle the glass, I was immediately seized with a very violent nausea, vertigo, horror, anorexia, &c. And hence we may readily account for the origin of abundance of diseases. Thus, for instance, it is no wonder if the bile, by stagnating, as it sometimes does, that is, by digesting in the warm human body, receives such a change as to produce the *cholera morbus*, with the nausea, vomiting, and other grievous symptoms wherewith it is sometimes attended. The salts of animal bodies, however, never become of an alkaline, or pernicious nature, but by heat, digestion, stagnation, or putrefaction; which latter is the consequence of stagnation, and never happens without it: but when once they turn volatile, or alkaline, the life of

D d

the

Processes upon Animals.

the patient is immediately endangered, by a gangrene, mortification, apoplexy, or the like. And whether the plague, the symptoms whereof succeed each other so fast, be not owing to some such cause as this, is a proper subject of inquiry for physicians.

CHEMICAL HISTORY of the *SERUM* of the *BLOOD*.

*Introduction to
the history of
the serum of the
blood.*

THE next animal fluid to be chose for the subject of our examination, is that which we know, by certain experiments, made in the physiological part of medicine, to be the sole, nutrimental matter of a healthy human body, which repairs the daily waste of all its parts. And this is no other than the serum of the blood; or to speak more accurately, some very subtile liquor separated from it; which not being obtainable, we take the *serum* it self. There can no doubt be made, that the body is supplied and nourished by means of the fluids which flow thro' all its vessels; but the *crassamentum*, or red part of the blood, flows thro' no other vessels than the larger veins and arteries; whilst the *serum* passes not only thro' the same, but likewise thro' the lymphatics, and the smallest canals, wherein the action of nutrition is required.

P R O C E S S CII.

*Shewing that the SERUM of the BLOOD is neither acid
nor alkaline.*

The process.

1. **T**O a proper quantity of the clear serum of human blood, add any the strongest acid, and it will make no manner of effervescence therewith, but lie perfectly quiet, or without visible motion. To another parcel of the same serum, pour any the strongest alkali, and in like manner no signs of ebullition will appear. Whence it is certain, that the serum of human blood naturally participates neither of an acid or alkaline nature.

*Confirmed and
applied.*

2. In like manner, if all the chemical methods of examining alkalies and acids were applied to the serum of human blood, they would never discover the least sign of either therein. But when the serum is fresh extracted, it has somewhat of a nauseous yet not fetid odour, like the scent of recent urine; and this is the natural smell of the fluids of our bodies, when in their most pure and uncorrupted state. When that violent acid, oil of vitriol, is added thereto, it becomes thicker and whiter;

whiter; but oil of tartar dilutes or thins it, yet without exciting the least conflict therewith; tho when the two different mixtures are put together, a violent one will immediately be raised. In its natural and perfect state, it is a transparent, viscous, uniform, and almost insipid fluid, nearly resembling the white of eggs; bating for its being something saline, on account of the sea-salt used by mankind along with their aliment. If it was really an acid, as *Sylvius* pretended, and by mixing with the alkaline blood, as he conceited it did, to keep up its circulation; the opposite salts thereof must upon such mixture raise a strong ebullition, and effervescence in the body; and so produce either violent tumors, or a rupture of the finer vessels, whereby life it self would immediately be endangered. And for this reason, we may safely reject his hypothesis, together with those of *Willis* and *des Cartes*, who feign'd such kind of effervescences in the animal body, to account for the phenomena therein. But it may be objected against our present experiment, that altho the serum which has long been extracted from the body, and suffered to grow cool, may manifest no signs either of a latent alkali, or acid contained therein; yet it may nevertheless contain them, whilst hot and circulating in the body. To obviate this objection, I have made a vast number of experiments, with the known acids and alkalies upon the blood of different persons, of different ages, and the different sexes, some of them labouring under fevers, or other diseases, as it came warm from the vein; but could never observe the least marks of any effervescence, or conflict.

PROCESS III.

Shewing that the SERUM of the BLOOD will putrefy by digestion.

1. **P**UT any quantity of the clear serum of healthy human blood into a ^{The process,} close, tall glass, and set it to digest in a moderate heat, not exceeding that of the body in a state of health, and it will gradually become thinner, and soon begin to smell cadaverous, and putrefy; so that at length, in a few days time, it will, like the white of eggs, turn to a perfectly alkaline ichor, and make a violent effervescence with acids; and if now committed to distillation, it immediately affords a quantity of alkaline salt, &c. exactly like the digested white of eggs.

2. If the digestion should be long continued, as for the space of several ^{Its effects, if continued.} days, the matter, or its oil, might be thereby rendered so intolerably fetid, as to make the operation dangerous; for the bare scent thereof would then be capable of doing much mischief, even at a distance.

3. Hence we learn the effects of a gentle warmth upon the blood; and ^{Its use in medicine.} see that this is a proper means to resolve it, when coagulated; and by making it finer, to render it fit to pass the smaller canals of the body,

Processes upon Animals.

where it would otherwise not enter at all, or cause obstructions. And this process alone will help us to cure and account for many diseases of the human body. Thus the viscous matter which lies like leather upon the extravasated blood of pleuritic persons, may by a gentle heat be almost wholly resolved again into serum: whereas if it should retain its tenacity whilst it was flowing in the vessels, it would cause obstructions, and be still more condensed therein. So, likewise, in all inflammatory distempers, to keep the body moderately warm is the way to thin the fluids, and hasten the crisis, or the discharge of the morbid matter, by encouraging or promoting some evacuation or other. But when the blood comes to be extravasated, and stagnates in any part of the body, suppose in the cavity of the thorax, or abdomen; being now no longer agitated by the force of circulation, it will first coagulate, then soon begin to resolve, and at length putrefy, and become alkaline, sharp, and corrosive; whence, if lodged in the cavity of the thorax, it might bring on a phthisis, by fretting away the tender substance of the lungs, or cause the empyema; or if in the abdomen, destroy the texture of the lymphatic vessels, whence they will distil out their liquor, and form the ascites. And after this manner may numberless other distempers be produced.

PROCESS CIV.

Shewing that the SERUM of HUMAN BLOOD is concrescible with a greater heat.

The process.

1. **L**ET a quantity of the recent serum of healthy human blood be received in a clean glass vessel, and exposed to a degree of heat somewhat greater than that it sustained in the body; then, without any considerable exhalation of its thin, aqueous part, or insipid water, it will immediately lose of its transparency, and form it self into a yellowish, viscous, membranaceous, fissile glebe, somewhat like horn, or parchment, not easily resolvable again, either by water, or salts.

Varied.

2. This experiment will also succeed, like that made with the white of eggs, if the serum be put into hot water; for by this means, it will be converted into such a mass as that above-mention'd: which shews that it does not coagulate for want of its aqueous parts: but if once it has been digested or suffered putrefaction, it will no longer concrete, either by means of a dry heat, or a moist one. And, accordingly, it has been found, that the blood of such persons as have died of the plague, could not be made to concrete at the fire, on account of the putrefaction which was then, perhaps, begun in the body. But, if on the other hand the serum for our experiment be extracted from a person soon after any violent exercise, it will coagulate much sooner than if it had been obtain'd from a person of a weak, hydropical constitution.

3. Hence

3. Hence we see the great affinity there is between the serum of the blood, and the white of eggs; as likewise the effects producible by fire upon the human body. And as an increased heat has the power of instantly coagulating the animal fluids; it is a present and effectual remedy in case of the bite of a mad-dog, or other venomous animal, immediately to burn the part with a hot iron, applied, or rather thrust deep into the wound. For, by this means the juices about the part being coagulated, and an eschar produced, all communication of the poison to any other vessels is stopp'd; and thus the cure may be readily effected: not that the hot iron draws out the poison, as is vulgarly imagined; but renders the parts incapable of being penetrated or affected thereby. And hence it is, that the pain occasioned by burns, may be lessened, or taken off by a fire, or a greater degree of heat than that which made them; for this will coagulate the juices about the part, and thereby render it less sensible of the pain. Thus a violent degree of heat, we see, destroys the parts of the body, or coagulates its juices; whilst a less dissolves and turns them into ichor. And the like effect will be produced by motion, attrition, or an increased velocity of the blood and juices, as well as by direct heat.

PROCESS CV.

Shewing that the SERUM of HUMAN BLOOD is coagulable with alcohol.

1. **MIX** a quantity of fresh serum of human blood with cold alcohol of wine, and it will instantly coagulate into a white, membranaceous, fissile mass, very difficult to be resolved again, and capable, in that state, of resisting putrefaction for many ages. The process.

2. In like manner, if the serum, or blood it self, be digested, tho ever so long, with pure alcohol, it will not become fetid, nor shew any signs of corruption; for neither will its salts turn alkaline, nor its oils putrefy: which indeed is very surprizing. I have my self digested them together for the space of six months, and found them of a grateful odour at the end of that time: and this may serve to shew us what a wonderful balsamic virtue there is in alcohol, which is plainly owing to its coagulating principle. And on this account it is, that those who are given to drink too freely of brandies, or spirituous liquors, are frequently affected with polypus's, or obstructions arising from the concretion of the blood in the larger vessels, the palpitation of the heart, the dropsy, dry crispy nerves, and other disorders of this kind, which prove generally mortal. Hence the wonderful effects of alcohol in sphacelations and spreading gangrenes; a most remarkable instance whereof occurs in the German transactions, where we find, that a very aged woman, at the Hague, having a violent gangrene, which spread from the

Processes upon Animals.

the middle of her foot, up one half of her leg; and the physicians declining to take it off by amputation, on account of her great age and infirmity; they ordered, to stop the growing evil, the part to be frequently fomented with rectified spirit of wine; which proved so successful, that, to their surprize, it not only prevented the farther spreading of the gangrene, but even embalmed the black and mortified part, dry as it was, like mummy; upon which the woman recovered and lived for two years after, with her leg thus preserved from farther alteration. And this relation may serve to shew, that gangrenes are not contagious, or of a spreading nature, but by means of the ichor, or corrupted matter which comes in contact with the adjacent parts. Hence also we may learn, that nothing can well resist the growth of animals more powerfully than alcohol; provided it be mixed with the serum, or that fluid which affords them their nutriment. And upon this is founded the method practised in *Italy*, and elsewhere, of procuring particular animals of a very little size. When they design this, they frequently rub the animal over with alcohol, or spirit of wine; which meeting with the nutritious juices in the extremities of the vessels, there gradually thickens or coagulates it, and thus increases the resistance of the surface against the force of the liquids, which would otherwise stretch out the vessels farther, and so increase the bulk of the animal. But alcohol is not the only thing that will thus coagulate the blood; as we shall see hereafter.

PROCESS CVI.

Shewing that the SERUM of the BLOOD, by gentle distillation, affords a water that is neither acid nor alkaline.

The process.

1. **T**AKE the fresh and clear serum of healthy human blood, and distil in a low glass, with a very gentle heat, scarce exceeding that of the human body in its natural state, and there will come over almost five sixth parts of an exceeding limpid water; which if examined by all the known chemical trials, gives no signs of its being either of an acid or alkaline nature; nor indeed of containing any saline matter or inflammable spirit; a dry mass remaining at the bottom of the receiver.

The doctrine it establishes.

2. Hence again we may be assured, that there are no volatile salts, or inflammable spirits, naturally contained in the blood; but that water, as it appears to be, is the most volatile part thereof. But if the serum should participate of the nature of the chyle, as it possibly may in a lax or weak habit of body, where the natural powers are too feeble to effect a thorow change of the aliment; or if the chyle should not be well mixed with, but remain floating upon the blood, the serum might perhaps afford an ardent spirit by distillation. But we here speak only of perfect serum, taken from a sound body, at a due distance of time after feeding.

feeding. It is also generally asserted, that the blood contains a copious volatile salt; but none can be made to ascend from recent serum, by the gentle distillation of our present process; tho it may be forced over the first in the following. We therefore venture to assert, that the most noble and most subtile part of the whole mass of blood, is that which approaches nearer to the nature of water than of any other known liquor. This may seem a paradox, but experiments abundantly support and confirm the truth thereof.

P R O C E S S C V I I.

Shewing that the inspissated SERUM of HUMAN BLOOD affords, by strong distillation, a spirit, a volatile alkaline salt, two kinds of oil, and an earth.

1. **A** Sufficient quantity of the remainder of the preceding process being ^{The process.} obtained, and cut into small pieces, so as to fill two thirds of a coated retort, gradually distil it in a strong heat, and it will afford a large quantity of a yellow, unctuous liquor, called the spirit of human blood, and next a dry volatile salt that sticks to the sides of the receiver; then, upon increasing the fire, a heavy ponderous oil will come over; all the lighter oil remaining mixed with the two other principles: here the operation is to cease, otherwise great danger may ensue. And now there will be left at the bottom, a black, spongy kind of earth, mixed with oil; which being calcined in an open fire, affords no fixed salt, unless it be sea-salt; all exactly in the same manner as in the analysis of the white of eggs.
2. The caution given in this process ought to be carefully observ'd, ^{The caution is requires.} as being a thing of the greatest moment; tho no author has hitherto taken the least notice thereof: for if after the spirit, salt, and oil of the serum are drawn off, the remaining mass be urged with a strong fire, it will fuse like bitumen, rise into the neck of the retort, block it up, and at length burst the glasses with prodigious violence, into a thousand pieces; at the same time filling the laboratory with a dreadful suffocating flame. Having once drawn off the spirit, salt and oil of human blood, in order to make *Helmont's* quintessence thereof, and urging the remainder with a very strong fire, to try if I could gain any phosphorus from it, other business happened to call me away whilst the operation was in hand; so that, at my return, I found a thick, brown, bituminous, or pitchy matter was risen into the neck of the retort, and almost filled it; upon which I apprehended the ensuing danger, and immediately retired from the laboratory, waiting the event at some distance without doors; and in a little time the vessels burst to pieces with a horrid crack, and instantly the whole place where I stood was filled, as it were, with lightning. Then rushing immediately into the laboratory, the flame I found was presently extinguish'd; which doubtless,

less, might otherwise have scorched the lungs, and proved instantly mortal; but it left behind it a very noxious vapour, exceedingly corrosive to the lungs. To avoid this danger, therefore, it may, when there is occasion to continue the process, be proper to perform it with a very large retort and receiver, and a very small quantity of blood, or serum. This caution ought by no means to have been omitted by those authors who have mentioned the experiment.

Its physical and medicinal uses.

3. From the preceding processes it appears plainly, that there is a very great affinity and similitude between the serum of the blood and the white of eggs; and that the serum is really the nutritive matter of the body, tho' not immediately, but remotely. The whole chick receives its nourishment and growth from the white of the egg; which is so attenuated and dissolved down by the heat of the brooding hen, as readily to enter and pass thro' the fine and delicate vessels of its tender body. In like manner, the serum of the human blood is so attenuated by attrition, or repeated circulations, and the heat of the body, as to pass thro' all its minutest canals, and become fit nutriment for it. But as by this continual circulatory motion, some particles of the serum will necessarily be so far attenuated as to become sharp and offensive to the body, nature has provided a particular organ, the kidneys, to discharge them, before they can have time to injure the curious structure. Hence, therefore, we are given to understand the difference there is between the urine and the serum; and why the salt of the former is more fetid than that of the latter; the necessity there is of a new supply of chyle to the blood; and the immediate cause of death from a want of food, to furnish new chyle, which is not required, upon its own account, by the body, but merely to replenish and dilute the blood, too much attenuated and rendered sharp by repeated circulations; whence, instead of repairing the tender vessels, it corrodes them: so that persons in this state commonly die apoplectic; the fine canals of the brain being first affected.

CHEMICAL HISTORY of the *ANIMAL SOLIDS.*

Introduction to the history of animal solids.

HAVING, in a few select and general examples, seen the nature, analysis, and principles of the animal fluids, our method next requires us to examine such of the animal solids as are most simple, pure, dry, and clear of the mixture of any heterogeneous matter; such are the bones, well freed of their fat, horns, hoofs, nails, hair, teeth, &c. And this we shall perform in one general example, which shews us the result of a larger number, severally performed upon these particular parts of animals.

PROCESS CVIII.

Shewing that the principles of the ANIMAL SOLIDS are the same with those of the animal fluids, by an example in the analysis of human bones.

1. **F**ILL two thirds of a retort with small pieces of undistempred human bone, which to appearance has lost all its moisture, or is grown perfectly hard, solid, white and dry; lute a large receiver to the retort, in the common manner, and in a sand furnace apply proper degrees of fire successively, and there will come over first a very large proportion of an inspid water. (2.) Upon increasing the fire, white fumes will arise, and fill both the vessels, and trickle down in veins like oil, into a sharp, oily, alkaline spirit, which by rectification in a tall glass, may be separated into phlegm, volatile salt and oil. (3.) Afterwards, a yellow, or white, dry, volatile, fetid, sharp, oily salt, ascends, and sticks to the sides of the receiver; and by degrees turns of a reddish colour, according to the quantity of oil that is mixed along with it. (4.) A light, volatile, fetid, yellow, and very fluid oil, comes over next. (5.) And at length, the fire being increased to the height, a ponderous, fetid, black viscous oil, will arise, and generally fall to the bottom of the spirit, if left in the receiver. (6.) What now remains at the bottom, is a very black, shining matter, composed of oil and earth, intimately united together; which being calcined in an open fire, falls entirely into white, inspid ashes, without affording the least quantity of fixed salt; only a little sea-salt, when the person whose bone it was had used that along with his food.

2. The productions and phænomena of the process will be much the same, whatever animal solid is made choice of for its subject; but bones thorowly dried, or the hoofs and hair of animals, seeming to contain less blood, or fluid matter than the flesh, or other parts, are the most unexceptionable, and fittest for the purpose; there being the least suspicion, that the extremities, or hardest parts of the body, which seem almost destitute of vessels, should contain such a quantity of pure water as is obtained from them by such treatment. And even the dryest animal substances will resolve, as well as the blood it self, by distillation, and afford it; tho not in so great plenty as the more succulent and recent. Whence we have a very clear proof, that water may be intimately united with the parts even of dry solids, and greatly contribute to compose them. I have frequently distilled hartshorn, which had been kept dry for several years, yet at the end of that time it has afforded a very copious water: and this principle doubtless contributes greatly to the cohesion of the terrestrial parts of bodies, as may easily be inferred from the consideration of the matter whereof bricks are made; which tho well dried and baked in the kiln, still keep the form given it by the maker; but when by the continuance of a violent degree of heat, the water comes to be totally

E c

exhaled,

*Observations
thereon; and
the uses of its
productions.*

exhaled, it presently falls to dust. After this water is once come over from the subject, a large quantity of fumes arise, which are of so subtile and penetrating a nature, that it is difficult for any lute to contain them in the vessels; whose insides they afterwards line with a copious alkaline, and exceeding volatile salt; so that if by rectification it be well purged of its oil; bladder and cork will not be able to keep it in the tightest glass. Once attempting to preserve of this salt by such means, in two years time I found the glass empty, yet to appearance firmly closed; the salt having all made its escape at the cork. I afterwards found the securest method to preserve this salt, was by keeping its oil along with it in a glass close stopped, and rectifying it as there was occasion. This indeed appears strange, and contrary to what one might reasonably expect, that the most solid, hard, inodorous and tasteless animal substances should contain, and so easily afford, large quantities of insipid water, and the most volatile and pungent salt. Care must be taken in this process, not to urge the remaining black, terrestrial matter with too strong a fire; for by that means it would, like the *caput mortuum* of human blood, be fused into a pitchy mass, block up the neck of the receiver, and burst the glasses, which might prove very dangerous to the operator. But if taken out in due time, or whilst it remains perfectly black and glossy, it may be properly called an animal coal; and is then an excellent remedy, of a very bitter taste, like all other adust oils, for destroying worms in the body; being taken fasting, in the quantity of about two scruples, or a dram, for a full grown person, mixed with a little hydromel, and walking after it. The same is also used as a pigment by painters, under the name of *bone-black*; for by continued grinding with oil, it becomes an admirable glossy black, for the purposes of their art. But when it comes to be calcined to white ashes, 'tis exceeding useful to assay-masters, and the purifiers of metals; as being capable of sustaining the most violent heat without fusing: of these ashes, therefore, reduced to impalpable powder, they chuse to make their tests and cupels; by mixing them up with a little water, and giving the composition what form they please. And by this means they obtain such vessels as will neither break, vitrify, nor any way foul the bodies committed to them, in fusion.

General conclusions from the foregoing processes, with regard to natural philosophy and medicine.

3. From the preceding processes we may draw this general conclusion, that urine, the white of eggs, serum, blood, flesh, bones, nails, hair, and all the particular animal fluids and solids, consist of and are resolvable into the same parts or principles. So that there is no foundation to expect specific or peculiar virtues in the water, spirits, salts, oils, or earths procurable by distillation from different animal subjects; for the native or presiding spirit, by the scent whereof it should seem that some dogs distinguish one kind of animal from another, appears to be lost in the operation. It is, therefore, the effect of fancy, more than the reasonableness of the thing, which occasions some authors to extol one particular volatile, animal salt, as a specific above all the rest. Thus some have

have been wonderfully fond of the volatile salt of hartshorn; others of that of the human skull; and *Helmont* would have it, that the salt of human blood is a much more excellent medicine than that of urine. *Goddard's* drops have been strangely celebrated, and recommended as a specific, tho' distilled from nothing but that animal substance raw or refuse silk, as it comes from the worm. But it appears by a thousand experiments, that there is scarce any difference discoverable between the volatile salts of different animal matters, let what parts soever of the animals be made choice of for that purpose: and consequently, the popular distinction made of animal salts into specific and not specific, is groundless and irrational; one being as efficacious and useful in any particular disease as another.

4. Nor are they only the animal solids and fluids themselves in substance, that afford these principles by distillation; but also the several preparations made of either. Thus the gelly, for instance, made by a continued coction of lean flesh, or purified bones, in clear water, is resolvable into the same. Dry and solid hartshorn, by distillation, affords a water, a spirit, a volatile salt, an oil, and an earth; but if it be boiled in several parcels of pure water, after the manner of our second and third process upon vegetables, till at length the water comes from it as pure and insipid as when it was poured on, the remainder will yield no salt at all by distillation, and but very little oil. On the contrary, if the several decoctions be exhaled to a gelly, or a higher consistence, and distilled, it will afford all the same principles with recent horn it self, before it was boiled. And the same holds true of all animal substances, as flesh, bones, and even ivory, or the like; tho' perhaps the experiment cannot always be made to perfection without the assistance of *Papin's* digester for the decoction; and sand, or other fit matter for the distillation.

5. Hence we see, that the basis of animal bones is mere earth, cemented together by means of water, and an oil that is not without great difficulty entirely separable from it. But when once it is deprived of this water and unctuous matter, it becomes like dust, and is no longer capable of burning or receiving farther alteration from the fire; whence all that is purely solid in animal bodies seems to be of a very fixed and unchangeable nature. But if oil be added to this dry powder, or skeleton of a bone, it will presently drink it in, grow hard again, and retain its form so long as the oil remains united with it. And hence, likewise, we learn the reason why bones that have long lain buried, or exposed to the open air, will not by distillation afford the animal principles; viz. because either by the moisture of the ground they are attenuated and putrefied, or rendered volatile by the action of the air and sun, so that they all fly off as in distillation, and leave nothing but ashes or fixed earth behind. In the last place, we learn from our present process, how it happens that flesh

boiled too long will not afford proper nourishment to the body; whilst the decoction or gelly thereof becomes exceedingly nutritive*.

CHEMICAL HISTORY of the *ANIMAL* PRINCIPLES.

P R O C E S S C I X.

Exhibiting the manner of separating, depurating, and rectifying the ANIMAL PRINCIPLES of the preceding processes.

The process.

I. **T**HE water which rises first in the distillation of the recent, pure, and undigested parts of animals, whether they be solid or fluid, being again distilled with a gentle heat, in a very clean vessel, will come over pure and insipid, without affording any thing of an inflammable, oily, or saline nature. (2.) If the volatile, alkaline, oily spirit, which comes over second, be in like manner distilled with a very mild heat, in a tall glass with a slender neck, it affords a white, pure, dry, volatile, alkaline salt, and leaves a quantity of aqueous phlegm behind, with some oil floating on its surface; which is the thing that before turned the salt of a red or yellow colour. But if the spirit to be rectified is not of an oily nature, as spirit of sal-ammoniac, for instance, it will by this means be separated only into a pure, volatile, alkaline salt, and a clear water, which remains at the bottom of the retort. (3.) The oil which ascends third in the distillation being well shook and mixed with warm water, imparts a copious, alkaline salt thereto; and at the same time loses considerably of its own acrimony: and if after the oil is thus cleansed, it be committed to distillation in a glass retort, with a very moderate heat, a much more subtile oil will come over, and leave a quantity of terrestrial matter behind it; and thus, by numerous repetitions of the operation, it would, like a vegetable oil, be at length almost totally converted into earth. (4.) The gross, ponderous, animal oil, that comes last over in distillation, being once or twice rectified in the man-

* The reader will observe, that all these processes are supposed to be performed upon the parts of sound animals, which enjoy'd a perfect state of health; and must expect to find a considerable difference in the phenomena, and effects of the productions, when the like experiments are made upon the corresponding parts of morbid animals. It were, therefore, greatly to be wished, that some able chemist would oblige mankind with an exact analysis of the animal solids and fluids, as altered by the various diseases whereto we are subject; which being compared with the set here offered the world, might lead us into a discovery of the cures of such diseases, in a more certain and effectual manner than those who are not chemical physicians can conceive.

ner just now mentioned, also deposits an earthy matter in the retort, and becomes more pure and light; approaching in its colour, scent, taste, and effects to the nature of the former. (5.) The fixed earth can only be separated from the remaining black and unctuous caput mortuum, by calcination in an open fire, which will gradually consume and drive away the gross oil; and by frequent ablutions in fair water to dissolve and purge it of its sea-salt; by which means it will at length become pure, white, and perfectly insipid.

2. This process shews us, (1.) That water is the finest and most volatile part of all the animal fluids and solids, whilst they remain in a healthy, natural, and unputrefied state; and not capable of being changed by mixing with the other principles, or of receiving any thing from them, unless it be a fine sulphureous, and somewhat fetid odour, which seems indeed to be strongly and intimately impressed upon it; and in which subtile sulphur its peculiar nature, or distinguishing property, seems to consist. (2.) That the distilled spirits of animal substances are nothing but a solution of the volatile, animal salt, in water, joined with a small proportion of the lighter oil; which, however, being less volatile than the salt, this is raised before it in gentle distillation: whence the oil comes to be left floating on the top of the water, wherewith it will not readily mix; the water now, upon a second distillation, becoming less volatile than the salt or oil, tho in the first it always rises before them. This solution, or mixture of three of the principles, is called by the name of spirit; not that it is simple and uncompound, as the principles of all things are supposed to be; but because it is volatile, and, like inflammable spirit, runs in veins or rivulets down the sides of the glasses in distillation. (3.) That the violent acrimony of animal oils consists in their salts, and are therefore made more mild and gentle by shaking them with warm water, which readily imbibes and dissolves these salts; leaving the oil more pure, and almost wholly convertible into fixed earth. Thus, having once well depurated a pound of the volatile oil of human blood, I did, by repeated distillation, turn the bulk of it into a terrestrial substance, in the same manner as Mr. Boyle had before converted vegetable oils, and particularly the oil of aniseeds, into a like matter; as himself expressly relates, in his discourse of the *Transmutability of chemical principles*. And therefore, when *Helmont* tells us, as he does in his *Aurora*, that in order to prepare the universal medicine, we must distil over the oil of human blood, so often as it leaves any faces behind it, he either commands what he never tried himself, or else designedly imposes upon his reader, and means no more than that he shall obtain such a medicine at *Latter-Lammas*; for tho that oil be distilled ever so many times over, it will still leave a faculent matter behind it. (4.) That the gross, animal oil has its excess of weight above the former, from the terrestrial matter wherewith it is united; whence it will sink to the bottom of the other liquid principles, before its rectification; which frees it from its earthy part, whereby it was made to appear like fluid bitumen, and renders

The doctrine
established by it.

renders it in all respects like to the pure oil that came over before it. Whence we may venture to assert, contrary to the common opinion of chemists, that tho' there appears to be two different kinds of oil, contain'd in animal substances, yet in reality they are but one, and differ only according to the quantity of earth that is mixed and united with them; of which however they may be in great measure deprived by repeated distillation, performed either alone, or with the addition of clean sand, or other convenient matter. And indeed, to speak strictly, there is but one single oil in all nature. (5.) That the earth afforded by animal substances, is the same with that afforded by vegetables; no difference, upon examination being to be found between them, unless perhaps that the earth of animals is the more attenuated. But as this earth has no particular medicinal virtue, any more than the water which first comes over, whatever be the subject it is procured from, 'tis manifest that all the virtues, or specific powers of bodies, as well vegetable as animal, reside in their oil, or salt; for their spirit, as we saw before, is no more than a composition of these two with water.

*The purification
and doctrine of
volatile salts.*

3. There are three different methods of depurating volatile salts; the first by distillation, in tall narrow neck'd glasses, with a very gentle heat, as before mention'd; by which means the salt will become more white, volatile, and less fetid; always leaving a quantity of oil behind; so that at length it seems to be wholly resolv'd into pure oil, and a saline matter: but this is not an accurate method of depurating and cleansing salts of their oil, which by remaining in them, tho' but in a small proportion, will in a short time turn them yellow. Another way is therefore commonly used to effect this depuration to better advantage; and this consists in well mixing six times their own quantity of dry, pulverized chalk along with them; and afterwards subliming the mixture in tall vessels, but with a gentle heat; whereby the salts will, at one operation, be rendered exceeding white and strong; for the oil is by this means drank into the chalk, and kept from rising by the heat which carries up the volatile salt. And this method is kept as a very great secret by those who make a living of depurating the volatile salt of hartshorn, as they call it. Yet neither does this perfectly answer the intention; for the salt thus depurated, will, by being kept for some months, at length change yellow, on account of a small proportion of subtle oil brought over with it in distillation. A third and more effectual way has therefore been invented and published by those excellent chemists, Cox and Slare, in the *Philosophical Transactions* of the *Royal Society* at London; which indeed is the best that has been hitherto discovered. Their method is upon a quantity of volatile salt, sublimed from chalk, to pour as much spirit of sea-salt as will serve to saturate it, or till the effervescence ceases; by which means there will be obtain'd a kind of sal-ammoniac; and if any oil remain'd in the salt, it will now be separated by filtering the mixture to dryness: then they add to the dry'd salt an equal quantity of salt of tartar, or pot-ashes, and afterwards sublime it in a retort; by which means they obtain a perfectly white, dry,

dry, simple, volatile, alkaline salt, entirely deprived of its oil, without considerably changing its nature; and therefore capable of being long kept without changing its colour. And when animal salts are purified in this manner, there is no difference at all observable between that of one substance and another, or between those afforded by the different parts of the same, or different animals, either in colour, taste, scent, or effects. Thus the volatile salts of urine, blood, bones, horns, hair, &c. appear to be perfectly the same, and no way distinguishable from each other, any more than the fix'd salts of vegetables, when well purged of their oil. Whence we may upon just grounds conclude, that there is in nature no more than one certain, determined, pure and simple, volatile, alkaline salt*; and that all the difference observable in different parcels thereof, is entirely owing to the different proportion of oil wherewith they are usually so intimately mix'd and united, that it is exceeding difficult to separate them; or when their whiteness is once lost to recover it, and make it permanent, by repeated distillation, or the particular methods of depuration before delivered. Just as we see in the bones of a skeleton, which tho' made perfectly white at first, will grow yellow with time; the oil, whereof they were not entirely deprived, exuding thro', and changing their colour. It is therefore certain, that the water, earth, and volatile alkali are perfectly alike in all kinds of animal substances; whose difference consequently must be owing to nothing but their oil; or, to speak more accurately, to something that, in a very small quantity, resides therein, which may properly enough be called the presiding spirit, and may be washed from it with water, as we formerly observed of the distinguishing spirit of vegetables. The saying therefore of the antient adepts, that the thing which sets the difference between one body and another, is the *small spark* predominant therein, proceeded from a knowledge of nature; and holds equally in animal as well as vegetable substances.

4 The salt, purified in the manner above delivered, is of an alkaline nature; or such as will make an effervescence with all the known acids, and imbibe almost twice its own quantity thereof, whereby it is convertible into a neutral or semi-volatile salt, like sal-ammoniac: and thus, if when taken into the body, it meets with no acid salts therein, it retains its own alkaline nature, and operates accordingly; but if it happens to unite it self with any acid, it presently becomes a kind of sal-ammoniac, and therefore resists putrefaction, and operates by sweat and urine; being also caustic and wonderfully volatile. The smallest degree of heat will cause it presently to exhale; as may be tried by laying it upon a warm metal-line plate; and even rises sooner alcohol than in gentle distillation. For which reason it acts less forcibly upon the solids of the body, than fix

* Considerable profit has been made by putting off the volatile salts of the cheapest animal substances, for those of the dearer; as particularly for salt of hartshorn, salt of vipers, &c. And it would be well if all the frauds of the trading chemists were as innocent as this.

salts, whose property it is to penetrate deep, and stick fast in the parts they stimulate; since upon being receiv'd into the stomach, and intestines, it must immediately by the heat thereof be continually reflected, and beat away from the sides toward the cavity: so that it is not at all probable, that it should ever, like fix'd alkali, pass the lacteals; but only act upon the *prima via*, by the effluvia into which it is rais'd with a moderate warmth. It is however a powerful, stimulating, aperient, diuretic, sudorific, and resolving medicine; capable also of promoting insensible perspiration, and of entering into the lungs, nostrils, and cavities of the head, and mouth, in the form of invisible effluvia, and of there stimulating the membranes, and altering the state of the person, either for the better or worse. Its caustic virtue is so great, that being externally applied to the flesh, it eats or burns it like fire; but in order to make it have this effect, it must, as we have formerly said, be covered with oiled bladder, or the like, to determine its force downwards, and hinder it from flying away by the heat of the body. But if managed in this manner, it will have a strong and sudden effect, so as in a little time to make an issue, or take off the hardest warts, or excrescencies in the eyes, as I have frequently experienced; and perhaps too the same might likewise be of service in schirrous and cancerous tumours. The use of this salt, by way of odour, is also excellent when any viscous matter or mucus oppresses the membranes of the nostrils, or is lodged about the *ossa frontis*, or *sphenoides*, &c. but if the membranes should already be too bare, its caustic quality might here render it very prejudicial, no less than if it were taken at the mouth: and indeed 'tis easy for the scent thereof, too frequently or too copiously received at the nose, to corrugate, inflame, or corrode the tender substance of the lungs, and cause a gangrene of the part, a peripneumonia, suffocation, or a phthisis. It is therefore a pernicious custom of the ladies, and especially of those who have weak and tender lungs, to be perpetually smelling at their pocket-bottles, filled with this pungent, volatile, alkaline and caustic salt. In its other virtues and respects, this volatile salt perfectly resembles the fix'd kind, obtained from vegetables by calcination. And indeed the only difference between them is, that the one is volatile, and the other fixed in the fire; this, when rendered volatile, seeming to constitute the very same species of salt with the other. Whence we may conclude, that fixed and volatile salts are but one and the same thing at the bottom: the fixed salt of vegetables being thus volatilized by the power of circulation, or other forces residing in animal bodies, after the manner of putrefaction; whereby vegetables themselves are made directly to afford no fix'd, but only a volatile salt.

The nature of
animal oils.

5. Animal oils, before their rectification, are of an exceeding adhesive or glutinous and acrimonious nature, on account of the saline and terrestrial parts mixt along with them, and the fire that is impressed thereon. But if by rectification, or repeated ablutions in warm water, they are once freed from their acrimony, or salt, they lose their caustic quality: and if the earth be entirely taken away, they remain no longer adhesive; but become

come more pure, subtile and penetrating; whence, tho being applied to the skin, they would before this depuration inflame, corrode, or even cause a gangrene of the part; they now become of a mild and innocent nature. And this will shew us that we ought not to be too liberal in the internal use of unrectify'd oils, because of the salt wherewith they abound; which might easily render them corrosive to the stomach, purse up the vessels thereof, or burn its coats, as it were, to a crust.

PROCESS CX.

Shewing that animal alkaline spirits will coagulate with alcohol, and give the offa alba of Helmont.

1. **T**O a proper quantity of a volatile, animal, alkaline spirit, that is well purged of its oil, saturated with salt, and contained in a glass vessel first made exceeding cold and dry, add an equal proportion of pure alcohol, in a place where the air likewise is very cold; then where the two transparent liquors touch each other, there will immediately be formed a plate of solid opake matter: but if the containing vial be shook, the whole mixture will instantly unite and coagulate together into a white solid mass; which may again be liquified by the least degree of heat; but in its state of coagulation cannot be made to fall out at the mouth of the glass.

2. This experiment will not succeed unless the alcohol be perfectly clear'd of all aqueous particles, and the volatile alkali be thorowly depurated, and rich in salt. Upon which account it has by some been treated as a mere fiction of Helmont, who pretends to the invention, tho without dispute Raymond Lully described it long before his time: but the thing succeeded not in their hands for want of due attention to the requisites. The alkaline spirit contains salt enough for this purpose, when some quantity will lie undissolved at the bottom thereof; and if the same be well freed from its oil, and the alcohol be also pure, success will attend the experiment.

3. The production or coagulum of this process is a wonderfully volatile and perfect soap; the alcohol being a most subtile oil, and the other spirit containing an alkaline salt, so highly attenuated as to become exceeding volatile. The virtues and uses of the mixture may therefore be understood from what we formerly said of soap; only in this case the ingredients are much more volatile than in the other soaps. By repeated distillation these two spirits may be intimately united; upon which their salt will shoot into crystals, consisting of thin flat plates; yet remain instantly separable again by the admixture of acids; tho the whole mixture is at the same time of an alkaline nature.

The cautions required to make it succeed.

Nature of the production.

Physical and
chemical uses
of the process.

4. This experiment shews us that the most fluid and volatile Bodies in the known world may be instantly turn'd to solids, by nothing more than bare mixture; which a person could scarce believe without the immediate testimony of his senses. Here likewise we have an instance of the great attractive power there is between volatile salt and volatile oil; as we formerly saw it betwixt alcohol and fix'd alkali in the preparation of *Helmont's* tincture of salt of tartar. But notwithstanding the strict union of the salt and alcohol in this coagulum, it has no pretence for being *Helmont's Alkahest*, as *Starkey* imagined; because it may so easily be destroyed by acids, or by water.

CHEMICAL HISTORY of VOLATILE OILY SALTS, made by means of sal-ammoniac.

PROCESS CXL.

Exhibiting the production of simple SAL VOLATILE OLEOSUM.

The process.

1. **T**O twenty-four parts of pure alcohol, add one part of any distilled aromatic oil, as of rosemary, for instance; mix them together into a liquid quintessence; and afterwards shake with them twenty five parts of highly rectified Spirit of sal-ammoniac, and immediately there will be made a coagulum, as in the preceding process; which being once or twice gently distilled over in a retort, till the dry volatile salt sticking to the sides of the vessels begins to dissolve, gives a simple sal volatile oleosum, or a volatile, saline and oily liquor.

How varied.

2. This sal volatile may be varied at pleasure, by the use of particular essential oils; the same proportion being always observed, and the two other ingredients remaining the same. Thus there may be made a sal volatile of cinnamon, citron-peel, &c. the liquor taking its denomination and particular virtues from the essential oils of those vegetables. And as the alcohol, the distilled oil, and the spirit of sal-ammoniac are evidently united in this liquor, it has by some been called the lesser animal elixir.

P R O.

PROCESS CXII.

Shewing the manner of preparing compound SAL VOLATILE OLEOSUM.

1. **MIX** together equal parts of any compound spirit of aromatic vegetables, The process. and the rectified spirit of sal-ammoniac, and distil them over twice or thrice with a gentle heat in a glass retort, carefully luted to its receiver; and what comes over is a compound sal volatile oleosum; the distillation being continued till the salt adhering to the glass just begins to dissolve.

2. The design of the process might likewise be effected with a mixture Varied. of different essential oils, as well as compound spirits; so as to yield a sal volatile of any medicinal virtues that shall be required. But if a dry aromatic salt, without any volatile spirit, be the thing in view; no alcohol need be added, and only a proper proportion of essential oil poured to the dry salt before obtained: then the operation being performed in the gentle manner above mentioned, a dry, white, aromatic saponaceous salt will sublime and adhere to the sides of the glasses. And thus all those commonly called by the name of *English salts* are constantly prepared*.

PROCESS CXIII.

Exhibiting the method of procuring specific SAL VOLATILE OLEOSUM; by an example in that of LAVENDER.

1. **TO** four ounces of recent lavender flowers, add twenty-four ounces of The process. rectified spirit of wine, two ounces of sal-ammoniac, and an ounce of salt of tartar. Put them together into a glass retort, and carefully lute it to a large receiver, and distil with such a degree of fire as will just serve to make the matter boil; upon which there will arise a volatile salt, in a dry form, possessed of the specific virtue of the plant; and afterwards a spirit of the same nature therewith, which is to be drawn off till the phlegm begins to rise, so as to dissolve the dry salt; and then the operation is to cease. But if what thus comes over be poured back upon a parcel of fresh flowers, the medicine will thereby be made the more efficacious.

2. If instead of lavender any other aromatic vegetable, of known speci- How to be varied for the purposes of medicine. fic or medicinal virtues be here made use of, its sal volatile oleosum may in like manner be obtained, under the particular name thereof. And thus may be made the sal volatile of rue, which is a good antihysterick; of favin, &c. which powerfully assists in expelling the foetus, or forward-

* These are the volatile salts which the ladies generally carry in their pocket-bottles; and usually by foreigners termed *English salts*.

ing delivery; or of opium, which has the power of stupifying almost instantaneously. And so the *sal-volatile* of other vegetable productions may be made to participate of their medicinal virtues.

P R O C E S S CXIV.

Exhibiting the extemporaneous manner of producing SAL VOLATILE OLEOSUM.

The process.

1. **R**educe equal quantities of pure salt of tartar, and sal-ammoniac to powder; put them into a clean glass vessel, and pour upon them twelve times their own weight of well rectified spirit of wine, and half as much of any essential aromatic oil, or a mixture of several kinds thereof, as of either of the salts; shake them all well together, and the fixed alkali will immediately volatilize the alkaline part of the sal-ammoniac; whilst it drinks in the aqueous moisture of the spirit of wine: whence, of course, the purer spirit, the essential oil, and the volatile salt will directly be united into a sal volatile oleosum.

History of the production.

2. The first who wrote of these volatile salts was *Basil Valentine*; but he delivered himself obscurely upon the subject. *Helmont* afterwards treats of them in his book of the *Stone*; where he is large upon the volatile salt of urine. But *Sylvius* was the first physician that introduced them into medicine; and he recommended them so earnestly, as an universal remedy, that it gave occasion to sell them at a very exorbitant price. After *Sylvius*, *Tachenius* prepared a volatile salt of vipers, and valued it highly as an admirable remedy against the stone and gravel: and in a short time after, these volatile salts were every where in general use and esteem.

Its medicinal uses.

3. All these kinds of *sal volatile oleosum* are most properly employed in such distempers where any acid humor is to be corrected, any thing viscid or tenacious to be attenuated, or any thing coagulated to be resolved; where heat is to be increased, the strength recruited, or sluggish motions to be quickened. Which gives to see how noble a medicine they are in abundance of chronical diseases, proceeding from a viscid, cold or acid cause; as particularly in the acid scurvy, and the acid gout. But, on the contrary, in acute cases, when an alkaline corruption resides in the body, and the blood, or oils thereof are already broke too small, it is very unsafe to use them, as being here of a very poisonous and pernicious nature. They must therefore be carefully avoided in case of a *phthisis*, where there is a disposition to bloody urine, or the like; and, in general, wherever the salts of the body are of an alkaline nature, or tending to putrefaction. When their use is proper, they are taken to best advantage, in a considerable dose, several times in the day, along with a glass of generous wine. To prescribe them after the vulgar manner, in the quantity of a few drops, is doing little to the purpose: they must be given by a dram at a time; so that a whole ounce, may, in cases of necessity, be taken

in a day, if we would expect to reap the benefit thereof. And in this manner I have prescribed them with good success. But if the internal parts of the body are to be altered or impregnated with their virtue, they ought to be taken upon an empty stomach, drinking a draught of some warm liquor upon them, whilst the patient remains in bed, or using gentle exercise after he rises, so as to cause a light appearance of sweat upon his body, or at least a disposition thereto. They are likewise frequently used externally, and may be readily made into a dry form for smelling-bottles, by a gentle sublimation in tall glasses; and thus they powerfully stimulate the nerves, and recover from epileptic and hysteric fits. But when applied too frequently to the nose, they may prejudice the lungs, or *membrana Schneideriana*. They also make an excellent potential cautery; being applied to any part, and covered with a piece of bladder to prevent their exhalation. And lastly, they admirably serve to discuss and resolve hard tumors; being diluted with a large proportion of water, and used in the way of fomentation; provided there are no signs of putrefaction in the body. Hence it is evident, that the use of these salts is indeed very extensive, tho not so universal as some have thought it, or as their extravagant commendations would persuade one.

CHEMICAL HISTORY of the BLOOD.

WE have now seen, in a competent number of select examples, the resolution of all the animal solids and fluids, of what principles they are composed, and what medicines they afford by composition. Nothing more remains to be done in this second part, which treats of the animal kingdom, than to shew what phenomena or changes are producible in the blood, by means whereof all the parts of animals are repaired, upon mixing it with the productions of our preceding processes, or the more active principles of bodies; as particularly with alcohol, oil, water, and different kinds of salt. This knowledge is so requisite to a physician, that it is impossible he should ever understand the effects, or explain the operation of medicines without it. To make these experiments with the greatest advantage, it seems most proper to chuse the *serum* rather than the *crassamentum* of the blood, or the mixture of them both as they come from the vein; for the effects will be nearly the same in both, but the *serum* is much the more commodious for experiments.

*Introduction to
to the history of
the blood.*

P R O-

PROCESS CXV.

Exhibiting the phenomena of the BLOOD upon mixing with various forms of salts, and oils, by particular experiments made on the Serum.

The experiments.

1. **E**XPOSE any quantity of healthy blood, newly extracted from the vein, for the space of twenty or thirty hours to the open air, in a clean vessel, and it will separate, as it cools, into two different parts, a light yellowish liquor, or serum, and a red, congealed mass, or crassamentum, that when separated from the sides of the vessel, appears like an island in the ocean, and sinks to the bottom of the serum^{*}; which, being decanted clear, and mixed with a proper proportion of warm water, to reduce it to the same degree of heat it had in the body, will, by being severally mixed with the following materials, afford the following phenomena.

2. Upon putting together equal quantities of the serum of healthy human blood, prepared in the manner above-mentioned, and the oil of tartar per deliquium, the serum appears rather coagulated than made thinner, and its colour immediately changes to whitish; an alkaline vapour arising from the mixture: which shews us the effect of fixed salts upon the blood.

3. If, in like manner, the same proportion of the pure and strong spirit of sal-ammoniac be mixed with the serum, it will be diluted or thinned indeed, but scarce discover any alteration in its scent or colour. Thus also, the like proportion of the strongest and most fiery spirit of the same salt, distilled with quick-lime, dilutes the serum, tho it neither alters the colour, nor makes any effervescence therewith; but gives it, however, an acrimonious taste. And the same holds good of the rectified spirit of digested urine: whence we are given to see the different effects of fixed and volatile alkalies upon the blood.

4. Add to the first mixture, viz. that of oil of tartar with the serum, any quantity of spirit of vitriol, and there will arise a strong effervescence and expansion; but it will scarce return to its former fluidity. The same spirit being poured to the second mixture, that with the pure spirit of sal ammoniac, affords the like phenomena. But if spirit of vitriol be added to the third, that with the fiery spirit of sal-ammoniac, it makes no manner of effervescence; but

* If there be numerous air-bubbles in the fibrous part of the blood, as sometimes is the case, it will not readily, or perhaps not at all, sink below the serum; the difference of their specific gravity being not very considerable: which has given occasion to some mistakes about this matter. To say the truth, it seems to have been little considered that the blood of different persons may differ as to its gravity; whilst we look upon blood, in the general, as a certain immutable fluid, that is con-

stantly of the same weight; tho the specific gravity of no fluid is absolutely the same for any two successive moments, and differs with the seasons of the year, heat and cold, the time of the day, &c. and so, in particular, does the blood with the several stages of life, changes of the body, diseases, and numerous other circumstances: whence it should seem that general conclusions ought not to be hastily drawn about this matter.

suffers

suffers it to remain, as it were, in its former state. And lastly, upon adding the same spirit of vitriol to the mixture of spirit of urine and serum, the effect will be the same as in the mixture of the serum, the pure spirit of sal-ammoniac, and spirit of vitriol; excepting that the inspissation is not so strong.

5. But if the spirit of vitriol be added to pure and unmixed serum, it will be instantly coagulated, and turned white thereby, as if it had been boiled at the fire: and then the addition of oil of tartar makes a violent effervescence. The spirit of sea-salt makes a perfect coagulation of the serum; but with very different phenomena from those occasioned by the acid of vitriol: and the addition of oil of tartar causes a considerable effervescence; at the cessation whereof the sea-salt is regenerated from its spirit. The spirit of nitre instantly makes a strong coagulum of the serum, in the same manner as oil of vitriol, and yields a copious effervescence upon the affusion of oil of tartar; after the disappearance whereof, the nitre is found to be regenerated. On the contrary, strong spirit of vinegar greatly dilutes the serum; and the affusion of oil of tartar here cannot make any effervescence, but coagulates the mixture.

6. A solution of sea-salt in water causes no change of colour in the serum of the blood, but dissolves its texture a little; tho without causing any effervescence. And the like solutions of sal-gem, borax, nitre, and sal-ammoniac, do much the same; except that borax causes no alteration in the texture of the serum. But Glauber's salt, or that which in England goes by the name of Epsom-salt, instantly makes a strong coagulum thereof, and turns it white, as if oil of vitriol had been mixed therewith.

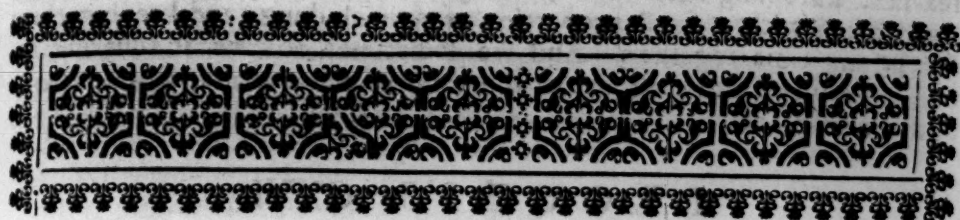
7. The affusion of sal volatile oleosum coagulates the serum on account of the alcohol it contains; after which, the addition of oil of vitriol makes only a moderate effervescence therewith. And, indeed, all saponaceous substances, which are a mixture of oil and alkaline salt, thin the blood, without causing any effervescence; tho of oil it self be added thereto, it prevents its mixing with water: but the tincture of salt of tartar, prepared with the purest alcohol, and the strongest fixed alkali, being mixed with the serum, preserves it in a neutral state; for the alcohol tends to coagulate, and the alkali on the contrary to dissolve it, whence it becomes neither thicker nor thinner thereby.

8. From the preceding particulars, we may draw this general conclusion, that the thing which strongly coagulates the blood in the human body is of an acid, and not of an alkaline nature; since all acids, except vinegar, are found to coagulate it, and all alkalies to dissolve it out of the body. Whence we may learn, that it was rightly judged of Hippocrates, tho he has been blamed for it, to prescribe the use of vinegar in ardent fevers, and all distempers proceeding from a lentor in the blood, or where it was requisite to dissolve or dilute it. And indeed vinegar appears to contain one of the most innocent acid salts in nature. But M. Homberg tells us in the *Memoirs* of the Royal Academy of Paris, that the spirit thereof concentrated, or reduced to its greatest strength, will, instead of dissolving, really coagulate the blood. And this I will not deny to be true; for I am sensible, to speak strictly, that acid salts do not coagulate the blood merely on account of their acidity, but

The doctrine they afford, as to the coagulation and liquification of the blood by medicines.

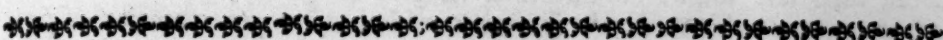
but by their austeriry, or constringing power, which presses or determines the liquor they are mixed with to a solid form; and which the vinegar may acquire by the operation. We see, however, that the direct method to dissolve or thin the blood in the body, is by the use of alkalies; which for that purpose need not be of the strongest or most fixed kind, which might sometimes prejudice the finer canals by their corrosive property; but such medicines as the tartarized, or regenerated tartar, the solution of the *sal Tachenii*, or the like, may be safely and advantageously used in case of coagulated juices: for these, at the same time that they dissolve, improve the colour of the blood, and render it more florid and healthy. On the other hand, it must be observed, that the exhibition of acids may frequently prove prejudicial, and especially in inflammatory fevers, by increasing the lentor or viscosity of the blood and juices, which by causing obstructions in the smaller vessels, give rise thereto; tho some are so ignorant as to imagine that acid salts have the power of fusing rather than coagulating the humors, and causing obstructions. But we may be certain, that hot water, aqueous solutions of vitriol, allum, salt of steel, sugar of lead, alcohol, and all acid spirits, vinegar alone excepted, thicken and coagulate the blood; and on the other hand, that cold or luke-warm water, aqueous solutions of sea-salt, sal-gem, nitre, borax, sal-ammoniac, regenerated tartar, and all alkaline spirits and soaps, under which vinegar may well enough be included, as containing a salt and oil strictly united, liquify and dissolve the same.





S E C T. III.

Exhibiting a Course of PROCESSES upon FOSSILS; the most irresoluble and inorganic Class of Bodies.



CHEMICAL HISTORY of FOSSIL SALTS.

METALS, tho the most simple of mineral bodies, are of a less tractable nature than fossil salts, and cannot be chemically treated without their assistance; for which reason we are obliged to open this Section of processes upon fossils with those, as preparatory to our examination of metalline bodies; and in particular with that salt which participates least of a fossil nature, or appears a kind of neuter in the three kingdoms; viz. nitre, or salt-petre.

Introduction to the history of fossil salts.

CHEMICAL HISTORY of NITRE.

THERE are generally reckoned three different origins of nitre: *Origin of nitre.* for first, it is found in lime-stones, or the mortar of old buildings; secondly, it is dug up in a fat soil, as in *Sumatra*, or particular parts of the *East-Indies*; and lastly, it is met with in those places where large quantities of the excrement and urine of such animals as use no sea-

sea-salt, have long been laid. It may likewise be obtained by mixing fixed alkali with a small proportion of animal dung, and keeping them for a long time together. And we sometimes observe it adhering to, or, as it were, growing out of the walls of wine-vaults, or other moist and warm places.

PROCESS CXVI.

Exhibiting the artificial method of procuring NITRE.

The process.

1. **R**Educe to powder a proper quantity of the friable lime of old walls, or the dry excrement of such animals as never use any sea-salt, after having long lain in large heaps exposed to the air; boil this powder in water, and it will communicate its saline parts thereto: then filtre and exhale the lixivium to a pellicle, and set it in the cold, where it will shoot or concrete into a saline lump, or nitre; which is cool upon the tongue, and almost tasteless, unless for a very faint bitterness it leaves behind.

How perform-
able to advan-
tage.

2. This salt might be obtained in greater plenty, if to the lime or other matter which affords it, were added a proper quantity of fixed alkali, or wood-ashes, sometime before it comes to be made use of. But if, instead of that, sea-salt, or sal-gem be added thereto, it will not be nitre that is obtained by the operation, but sal-ammoniac. And after this manner they make salt-petre in different parts of *Europe*, from a fat kind of earth, dug up in particular places, and capable of affording it to profit. But all that is brought to us from the *East*, is purely fossil, or what they dig in substance from the earth; and this generally appears of a brown colour. But whether the nitre of our times be the same with that of the antients, may be justly questioned. They generally called their nitre by the name of *Cyrenaic* or *Egyptian*, in which places it was found common, as there concreting from the urine of animals. And by comparing the account which *Dioscorides* gives of it, with that of *Hippocrates*, it is plain that their nitre was no other than our sal-ammoniac; the virtues which they deliver of the former, perfectly agreeing with those of the other.

Characters of the
production.

3. This salt of it self is neither acid nor alkali, tho it may easily be converted into either. It fuses at the fire with more ease than any other salt, and as readily dissolves in water: when pure it is not at all inflammable, nor yields any sparks in the fire. But if any salt or oil remains fixed to it, that indeed may flame, as being the only thing in nature that is inflammable. And so if sulphur be thrown upon it whilst it is in fusion, it will then be more strongly agitated, and thereby rendered still the more inflammable: so that tho of it self it be, contrary to the common opinion, incapable of taking fire; yet it may and does contribute to increase the flame of the sulphur, by adding to the motion of its parts. This salt has likewise a very refrigerating faculty;

faculty; so that it not only cools water, but allays the heat of the blood better than any other salt whatever; and indeed is the only one that will produce a considerable degree of cold therewith: on which account I highly esteem it in inflammatory distempers, where sea-salt would increase the heat instead of allaying it.

P R O C E S S CXVII.

Exhibiting the manner of purifying native or common NITRE, by crystallization.

1. **B**OIL any portion of native or lump-nitre, in six times its quantity of fair water; and whilst the lixivium remains hot, run it thro' the filtre into a wide vessel, with a flat bottom, and exhale it over the fire till a pellicle appears on the surface: then place several small sticks of wood, from side to side, in the vessel, below the liquor, and set it in a cool place to shoot; upon which, saline transparent glebes or crystals, in the figure of hexagonal prisms, will presently be found adhering to them; and these glebes are pure, crystalline nitre, fit for medicinal uses, and the other purposes of human life.
2. No salt runs into crystals so soon as nitre; whence, if it be not very hot whilst it passes the strainer, it will concrete and grow hard by the way. It ought to be set to shoot in a wide vessel; for this will make the crystals the larger and fairer. But if there be any suspicion that another salt is mixed along with the nitre, let the operation be repeated, and now boil the lixivium with a small proportion of fixed alkali; skim it well, and pass it again thro' the filtre; lay sticks in the containing vessel, as before, and suffer it to crystallize afresh; and by this means it will be made perfectly pure. Which is the method used by the workmen at the salt-petre mines, to free their nitre from any unctuous matter that may happen to adhere thereto, and prevent its shooting: for this addition of fixed salt draws to it as well the oil as the superfluous acid that is mixed along with it, yet without cleaving to the nitre it self; which is wonderfully prevented by the separating principle of crystallization.
3. This is the proper and highly useful method of separating and purifying all manner of salts by means of crystallization; which is the only genuine operation that gives to every salt its purity, form, and peculiar nature, or marks which distinguish them from all others, wherewith they might be accidentally united; for tho' any number of different salts should be promiscuously blended in the same common lixivium, yet if this were set in the cool to shoot, the salts would separate from one another, put on their proper form, and appear in peculiar crystals, according to their respective natures. Crystallization, therefore, is an incomparable method of separating one salt from another.

Directions relating to it.

Its chemical use.

Farther im-
proved.

4. If the nitre purified in this manner be put into a crucible, and once fused at the fire, where it will run with great facility, it thereby becomes the most perfect nitre that can well be obtained; being thus every way freed from its oil, which might render it unfit for several uses, as particularly for making good *Aqua fortis*, or good gun-powder. And this is the nitre that I constantly make use of, both in chemistry and medicine, without the addition of any other matters, which, instead of improving, really alter its nature, or render it impure. And whoever makes trial of it, thus prepared, will find it an admirable refrigerating and resolving medicine, most highly serviceable in ardent fevers, and other acute diseases. And if it be boiled in a decoction of red poppy-flowers, and the solution be filtered and crystallized in the manner already mentioned, it will be turned to a beautiful red, transparent salt, which has formerly been sold at a very high price, as an admirable and most effectual medicine: for by this means it is so neatly disguised, that it cannot well be distinguished; and is certainly endowed with very great medicinal virtues.

P R O C E S S CXVIII.

Exhibiting the method of converting purified NITRE into fixed alkali, with tartar.

The process.

1. **T**AKE equal quantities of purified nitre and clean Rhenish tartar, and grind them together to a fine powder, small parcels whereof being, at due intervals, put into an iron vessel made almost red-hot, there will a great deflagration be made at every injection, with a violent effervescence and ebullition; and at length, when in this manner all the powder is thrown in, it will presently be totally changed into a green and violent fixed alkaline salt.

What caution
it requires.

2. Regard must be had in this operation not to inject too large a quantity of the powder, at once, into the iron vessel; which might prove of dangerous consequence; for it immediately takes fire, like gun-powder.

Its effects.

3. Here we see that nitre, which of itself will never flash in the fire, may readily be made inflammable by the injection of tartar, a vegetable acid salt, containing a copious oil; and thereby be instantly converted into fixed alkali: which indeed is the most expeditious method hitherto known in chemistry of procuring it. And this may serve to shew us the natural affinity there is between nitre and vegetable salts, since it may so easily be changed into them.

Uses of the
production.

4. The production of this process may be used in all cases, whether medicinal or chemical, where fixed alkali is required; being it self really a fixed alkaline salt, of a very violent nature, and as such acting even upon metals.

PROCESS CXIX.

Exhibiting the manner of converting purified NITRE into fixed alkali, with a glowing coal.

1. **FUSE** a proper quantity of pure pulverized nitre at the fire, and when The process. it runs put a small portion of live charcoal, or other kindled vegetable fuel, into the crucible to it, and a great flash, attended with a considerable report, will presently break out; then, the former being consumed, throw a fresh coal into the crucible, and repeat the injection till the flashing and report entirely cease; upon which the remaining nitre will be turned into a blue-coloured fixed alkali, stronger than almost any other that can be procured, or as violent as salt of tartar it self.

2. In this process, also, the quantity of fuel injected at once should not be large, for fear of any mischievous effect, by the bursting of the crucible; the explosive force being frequently so great as to throw out the injected coal with a considerable violence. And this happens altho the nitre it self is not actually kindled; but as it thus strongly agitates the coal, it causes it to flash with great violence. What caution it requires.

3. Hence we learn, that a fixed alkali is producible by a small quantity of fire, or without the assistance of a thorow calcination; and that its chemical effect. the whole body of nitre is thus convertible into alkaline salt, unless perhaps its spirit flies off in the operation, in the form of vapour, which is not prejudicial, but wholesome to the body, and said to be a preservative against the plague.

4. If this fixed alkali be exposed to the moisture of the air, it is thereby presently made to run, like salt of tartar *per deliquium*, into an unctuous, alkaline liquor, which *Glauber*, its inventor, took for the alkahest: but in this he was grievously mistaken; such liquor being no more than the alkali of nitre, fixed by the inflammable vegetable used in the preparation, and run into a fluid by the moisture of the air, which it strongly attracts. What led *Glauber* into this mistake, was its great power as a menstruum, whereby it dissolves various bodies; tho in reality it is scarce preferable, for that purpose, to oil of tartar made *per deliquium*; having entirely the same virtues therewith, except perhaps it is of a somewhat more penetrating nature. There is, however, a remarkable book in *French*, which I have seen, wrote entirely upon this subject, by a jesuit, under the title of *The universal medicine*. Nature of the production.

PROCESS CXX.

Exhibiting the manner of Converting NITRE into Sal Prunellæ, with Sulphur.

The process.

1. **T**O a proper quantity of pure nitre, fused at the fire in a crucible, throw a small proportion of sulphur, not exceeding the twentieth part thereof; and there will instantly ensue a very smart fulmination, with so bright a flame, that it proves almost too strong for the eyes. When this phenomenon ceases, the same quantity of sulphur may, in like manner, be injected, and the operation repeated for two or three times; then the sulphur appearing to be wholly consumed, the remaining matter is to be poured out to cool, under the name of Sal Prunellæ.

Its use.

2. This process shews the foundation, and possibly the origin of gun-powder; nothing being here wanting but the coal, to constitute that destructive composition: and what service the coal performs therein, may be learnt from the preceding process. The production is called Lapis or Sal Prunellæ, not that it is ever obtained from the plant self-heal; but because the Germans observing it to cure the inflammatory, or gangerous species of the Angina, which they term *de Brune*, as effectually as the Prunella, they affixed that appellation thereto: tho to speak the truth, the pure nitre, without addition, or without undergoing this operation, seems, in this case, to be a much better medicine, and more adapted to the cure of the quinsy.

PROCESS CXXI.

Exhibiting the manner of Converting NITRE into Sal Polychrestus, with Sulphur.

The process.

1. **G**RIND equal quantities of purified nitre, and the finest sulphur, together, into a subtile powder, to be thrown, by small quantities at once, into a clean, ignited crucible; and upon each injection there will immediately arise a fulmination, like that of gun-powder: which being over, the operation is to be continued till the whole mixture of the nitre and sulphur is thus deflagrated. What now remains in the crucible must be fluxed, or continued in a calcining heat, for the space of half an hour; then the vessel being suffered to cool, take out the matter, and preserve it under the name of Sal Polychrestus.

Varied; with the virtues and uses of the production.

2. This process might otherwise be performed by frequently injecting small portions of sulphur upon the fluxed nitre, in the manner of the preceding, till what is thus cast in amounts to an equal quantity, or till the matter fulminates no longer, but only flames like sulphur. And the

the salt obtained in either manner, may, by repeated solutions, filtrations and exhalations, be reduced to any desired degree of purity. This is a salt of a peculiar nature, being semi-saline, and semi-sulphureous, neither acid nor alkaline, but somewhat bitter, and exceedingly like that mineral or fossil salt which is dug up in such pits as lie near the veins of some mineral springs. On account of its numerous medicinal virtues, it has obtained the name of *Sal Polychrestus*; and accordingly it is called by the French, *Sel de plusieurs usages*, the salt of many virtues. And indeed it is a noble medicine in all those acute diseases which are curable by aperients, and refrigerants; this salt producing its effects, without causing any inflammation or disturbance to the body. It is the most powerful resolver of all the salts hitherto known; being without equal, and very different from all others; as consisting of the fixed parts of nitre and sulphur, strictly united together. Taken in the quantity of a dram, in the morning fasting, 'tis an admirable, gentle cathartic; half a dram proves a sudorific or diuretic; and in the dose of two drams, it will generally prove a moderate emetic. In all mild intermitting fevers, it is as infallible as the *cortex*; being given in a proper dose, dissolved with some convenient liquid, two hours before the fit is expected. It likewise wonderfully disposes the body for the cure of obstinate quartans; and will sometimes even effect the cure it self. Being a neutral salt, it is likewise so innocent that it may safely, and to advantage be given in continual fevers; and I have always found it is of very great service in epidemic cases. In short, it performs as much as can well be desired of a medicine, and answers all the various intentions of the physician with the greatest ease and safety.

PROCESS CXXII.

Exhibiting the Distillation of Spirit of NITRE with Bole.

1. **T**O one part of purified nitre reduced to fine powder, add three of the dry powder of common red bole-armeniack, and grind them together for a considerable time, the longer the better; and with this mixture fill two thirds of a low, coated retort, made with a large neck; set it in an open fire, lute on a capacious receiver, with the lutum sapientia, so that it may lie horizontal, and carefully distil with due degrees of heat; by which means there will, with a slow fire, come over, for the first two or three hours, an acid, pale, watery liquor: when this is all risen, increase the fire, and a kind of unctuous spirit will begin to ascend, and keep coming over for two or three hours more: after this is all come off, increase the fire again, till red fumes appear in the glasses; and continue the same degree of heat as long as any of them are to be seen; then give the last degree of fire, and keep it up for two or three hours, so as to make the retort red hot; upon which the fumes will seem of a dark red, and a red liquor will come over. When this ceases to run, let the fire go out, and the vessels

vessels cool. The liquor that will now be found at the bottom of the receiver, is a smoaking and exceeding acid spirit of nitre; whilst only a parcel of dry bole, to appearance, remains at the bottom of the retort. But if any salt be still mixed therewith, it is not converted into fixed alkali, but may, by solution in water, filtration, and crystallization, be reduced to the form of nitre again.

Cautions relating to it.

2. The production of this process should not be rashly approached; and care ought to be used in pouring it out of the receiver into the vessel designed to keep it; for if this be imprudently done, it may prejudice the lungs by its corrosive fumes. The spirit of nitre, therefore, is most properly handled, or poured from one vessel to another under a chimney, which may give passage to its effluvia. And in order to detain and keep this spirit in the glass, it must either be stopped down with a glass-stopple, or one of wax; for it would presently eat thro' cork.

Its effects.

3. We learn from this experiment, that the fire greatly attenuates nitre, when prevented from flowing therein by means of bole, dried clay, or the like, so as to render it volatile, and turn it into an exceeding acid and unctuous liquor, which may be called the spirit of nitre, or *Aqua fortis*; being indeed the general basis of the menstrua for metals, and the only one that dissolves the human *calculus*; tho not capable, on account of its corrosiveness, of being taken internally. But if this distillation was to be made in an earthen vessel, without addition, the nitre would pass thro' the pores thereof, and not be separated or changed into an acid; which shews us the use of the bole in this process.

And transmuting faculty.

4. Hence we infer that the fire has a surprizing power of converting a fixed, neutral, and almost tasteless salt, into a violent acid, volatile and corrosive liquor; at the same time giving it a strong solutive power, whereby it acts even upon metals themselves: for nitre of it self is no solvent of metals, tho its spirit dissolves them so powerfully. And it is very remarkable, that the whole body of the nitre is thus convertible into this acid, without any separation being made thereof into its principles; for, as we before observed, if the fire has not been violent or long enough continued to drive it all over, what remains mixed with the bole, is really and truly nitre; so that the spirit obtained by our process is an actual transmutation of the nitre. And in the same manner may acid spirits, otherwise called oils, be procured from the other fossil salts; as particularly vitriol, tho this requires a particular, cautious treatment, and a violent fire for the purpose.

PROCESS CXXIII.

*Exhibiting the preparation of Aqua fortis, or Glauber's Spirit
of NITRE, with oil of vitriol.*

1. **T**O a proper quantity of purified nitre, well dried, pulverized, and put The process.
into a dry and strong glass retort, carefully pour an equal proportion of
pure oil of vitriol, avoiding the noxious fumes, so that the whole mixture may
not possess more than two thirds of the retort: red fumes will instantly arise in
the glass; then presently lute on a large receiver, with the lutum philosophorum,
and distil with degrees of fire, in a sand furnace; upon which the vessels will
soon be filled with fumes of a colour between black and red; then the fire be-
ing increased thro' all the degrees, and the operation continued till nothing fur-
ther comes over, let the glasses cool, and there will be found at the bottom of
the receiver a real Aqua fortis, or a much more corrosive, acid, and fiery spirit
than that of the preceding process; being so volatile as spontaneously to go off
in red, copious, suffocating fumes.

2. This is the strongest and cleaneſt ſpirit of nitre that can by any means be procur'd; and the beſt for chemical uſes, or in all thoſe caſes where it is required pure and genuine: for it is, in reality, only the body of the nitre it ſelf, and not the oil of the vitriol, as might be ſuſpected; which is manifeſt from hence, that pure nitre may be again recovered from the liquor. But that which riſes firſt is weaker and leſs efficacious than the production of the preceding proceſs. The fumes of this ſtrong ſpirit are to be carefully avoided, as highly ſuffocative, in opening the containing glaſs; which likewiſe muſt be ſtopped with wax or a ſtopple of glaſs, for its parts would readily paſs thro' wood or cork. *Glauber* was the original author of this proceſs, who made a great advantage of the production, by keeping it for ſome time ſecret, and ſelling it, at his own price, to the chemiſts of different countries; among whom it was uſually called the blood of the ſalamander; on account perhaps of the colour of its fumes, and the vehement fire required to raiſe it. And in the ſame manner the acid ſpirits of al- lum, &c. are obtainable by mixing them with oil of vitriol.

3. Hence we see that oil of vitriol has the power of volatilizing salt-petre, and of turning it from a neutral salt into an acid spirit, without leaving any faces behind: for if any part remains unconverted into this fluid acid, it unites with the oil of vitriol, and changes into a third body*. And thus we see that nitre is convertible into acid, as we before saw it was into alkali. We may add, that it should seem from

*Chemical effects
of the process.*

* The remainder of this process is a fine, white cake of salt, commonly called the *Sal entium Paracelsi*; whose virtues and uses are much the same with those of *Tartarum vitriolatum*, for which it is frequently sold.

the effect of the oil of vitriol in the present process, that this liquor is a kind of concentrated fire, as here producing the same change that a vehement fire did in the foregoing; excepting only, that a considerable part of the nitre in the present process remains fixed with the oil. At least the spirit of nitre it self appears to be of an igneous nature; since being mixed with the essential oils of cloves, carraway-seed, saffrafras, or the like, it causes them instantly to flame, with a great explosive force.

P R O C E S S CXXIV.

Exhibiting the method of preparing Spiritus Nitri dulcis, or the sweet spirit of NITRE.

The process.

1. **T**O a proper quantity of Glauber's strongest spirit of nitre, contained in a tall glass, first made hot, and placed under a chimney to carry up the pernicious fumes, carefully pour, by slow degrees, thrice its quantity of pure alcohol of wine; and immediately after every affusion there will arise a violent effervescence, with a considerable degree of heat; sparks of fire also frequently appearing to be generated in the struggle; and the grateful scent of green southernwood being diffused about the room. After the whole quantity of the alcohol hath been thus poured to the spirit of nitre, set the mixture to digest for the space of twenty-four hours or more, the longer the better, that the acid salt may be thoroughly dissolved; and thus there will be obtained a dulcified spirit of nitre*; so called, as being deprived of its acrimony, and the power of dissolving silver.

The caution it requires.

2. This process requires a great degree of care, to prevent its being prejudicial to the operator; but may be performed with much less danger, by using a weaker or more aqueous spirit of nitre, and only rectified spirit of wine; which being mixed together in the same proportion, and after the same manner, as above-mentioned, will have a gentler ebullition, and not cause that violent evaporation of the fluids concerned, tho they otherwise yield the same phenomena with the former.

Virtues and uses of the product.

3. By means of this process we obtain an acid *sal volatile oleosum*; the virtues whereof are truly admirable in all diseases, whether internal or external, attended with putrefaction. It is particularly excellent in case of the stone and gravel, being taken, with any proper vehicle, in the quantity of twenty drops, three or four times a day; and in this respect it was a gainful medicine to the famous *Sylvius*. 'Tis likewise good in such colics as proceed from a bilious, hot, or putrid cause; and one of the best medicines yet known in case of a gangrene or

* This spirit is usually ordered to be distilled from the mixture with proper degrees of fire, the juncture of the vessel being not luted at all, or but slightly; and this operation seems

requisite to break the points of the salt-petre, and more effectually to dulcify or mitigate the spirit for internal uses.

sphacelation

sphacelation. It may be safely given in case of a cancer, even tho designed for extirpation; for even then it will contribute to make a separation of the corrupted from the sound part whereto it is contiguous. Lastly, it has, when properly applied, very great virtues, both in the small-pox and plague.

PROCESS CXXV.

Exhibiting the Regeneration of fixed NITRE, by means of fixed alkali.

1. **U**PON a proper quantity of Glauber's spirit of nitre, pour, by de- The process, grees, the lixivium of the fixed alkali of nitre, or, which is all one, oil of tartar per deliquium, and a violent effervescence will immediately ensue: continue thus pouring on the lixivium till the point of saturation is obtained, that is till the mixture ceases to bubble, or till it appears to be neither alkaline nor acid: then filtre the liquor, evaporate it to a pellicle, and setting it to shoot in the cold, it will run into crystals; which, if the point of saturation was nicely hit, cannot, in any respect, be distinguished from genuine nitre.

2. This is that noble experiment upon nitre, of which Mr. Boyle has ^{its use;} wrote an entire treatise, under the title of the Redintegration of nitre; and certainly shews, that a mild neutral and innocent salt, at least exceedingly like native nitre, may be generated from a known fixed alkali and strong acid. It would, however, be too hasty to conclude from hence, that all nitre must needs be produced in this very manner; for the same salt may have different origins. Some there have been, who question whether the salt thus obtained be really and truly nitre; but no scruple, methinks, need be moved upon that head; since by distillation with oil of vitriol, it undoubtedly affords the spirit of nitre.

PROCESS CXXVI.

Exhibiting the regeneration of semi-volatile NITRE, by means of spirit of sal-ammoniac.

1. **I**F instead of the oil of tartar in the preceding process, the alkaline spi- The process, rit of sal-ammoniac, prepared with salt of tartar, be added, after the same manner, to spirit of nitre, the phenomena, upon continuing the experiment, will be the same; only the actually nitrous crystals, into which the liquor shoots, will be thinner and lighter, and, like sal-ammoniac, semi-volatile.

2. Hence we see that from the union of acids and alkalies, there ^{its chemical} may proceed salts retaining the nature of the body which affords the ^{physical use.} acid, but receiving their degree of fixedness from the alkali: thus from the spirit of allum, vitriol, &c. allum, vitriol, &c. may be procured. And

Processes upon Fossils.

as there are but two kinds of alkalies in all nature, viz. fixed and volatile, the nitre regenerated in this manner, will either be fixed or semi-volatile. If therefore we could conceive, that alkaline spirits may meet with the acid of nitre under ground, it were easy to imagine how nitre is there producible: but that this is ever really the case, seems hard to say. We see however, that it is possible for caustic alkaline salts to fix a caustic acid, and thereby form themselves into a neutral salt, that is neither acid, nor alkaline.

PROCESS CXXVII.

Exhibiting the production of NITRUM NITRATUM, acid NITRE, or the impregnation of NITRE with its own spirit.

The process.

1. **T**O the filtered solution of nitre made in water, add a few drops of the spirit of nitre, sufficient to give a manifest acidity thereto; then evaporate the mixture to a pellicle, and in the cold it will shoot into perfectly nitrous crystals, but of an acid taste; which are the nitrum nitratum, acid nitre, or salt-petre impregnated with its own spirit.

Its uses.

2. This process gives us a method of essentification, as it is called, or of saturating any kind of salt, or turning it acid, by means of its own spirit; and thus tartar, sea salt, &c. may be essentified. But nitre treated after this manner has very few known uses; being remarkable for little more, when not made too sharp, than quenching thirst, and keeping the mouth cool and pleasant in burning fevers, being laid upon the tongue: tho it might likewise be properly employed in all putrid diseases: and in hot climates it will excellently serve to cool and refresh their liquors, so as to render them wholesom, and potable with pleasure.

PROCESS CXXVIII.

Exhibiting the production of vegetative NITRE, or the preparation of Glauber's sal mirabile of SALT-PETRE.

The process.

1. **I**F after the distillation of Glauber's spirit of nitre, as mentioned in the hundred and twenty third process, the white, odd kind of salt, that remains at the bottom of the retort be calcined, and dissolved in water, the solution filtered, evaporated over the fire to a pellicle, and set in a cool place, it will shoot into an uncommon kind of crystals, that are not referable to any species of the known salts; being neither nitrous, vitriolic, nor of kin to sea-salt, but of a new nature, peculiar to themselves; and having this peculiar property, a wonderful tendency to chemical vegetation; whereby they form themselves,

selves, as it were, into a kind of trees, different from all the crystals of other salts; but approaching nearest to the nature of tartarum vitriolatum.

2. This experiment may be reckoned among such as are contingent; *odd effects thereof.* for we cannot always produce these crystals, nor assign their precise figure before-hand. But if the distillation of the spirit of nitre be not long continued, or but just till the spirit is all come over, and the remaining matter be then committed to a large vessel, in a still cool place, its upper surface will, like a fruitful soil, appear covered, in a wonderful manner, with a kind of crystalline vegetables; and if these crystals should at any time be dissolved or destroyed by heat, upon placing them in the cold again they will again begin to shoot, and give signs of vegetative life, sometimes discoverable by the naked eye. *Virtue of the preparation.*

3. If the salt of this process be ever so often dissolved in water, and suffered to shoot again, it forms it self into the same kind of crystals it before appeared in; but becomes purer and purer by repeated operations. Its medicinal virtue is aperitive, and differs not considerably from that of tartar of vitriol; the process whereof we shall describe hereafter.

CHEMICAL HISTORY of SEA-SALT.

SEA-SALT appears to be every where contained in the water of the great seas, which being evaporated by the heat of the sun in the hotter climates, leaves a parcel of dusky saline glebes, that is, crude sea-salt, behind it. If this crude salt be dissolved in about four times its own quantity of the same sea-water, boiled, skimmed, decanted from its faces, evaporated to a pellicle, and set in a cool place, it concretes into hollow, pyramidal crystals; which being again dissolved, and several times treated as before, they at length appear in the form of a very dry and perfectly white salt, too well known to need any farther description; this being the common salt that is used at the table. But if these depurated, dry crystals be put into a clean glazed vessel, that is close covered, and set over a clear fire, they will, for a long time, continue to crackle with a considerable noise, and lose one third of their weight in the operation: and this is called the decrepitation of sea-salt. If when the crackling ceases, and the salt is reduced to a greyish kind of powder, it be fused in a crucible, then dissolved in water, filtered and crystallized again, it becomes more pure and perfect than any other salt, well fitted for chemical operations, and exceedingly approaching to sal-gem. And in this method we ought constantly to purify sea-salt, for the uses of chemistry; because naturally it is always mixed with some impurities of the fishes, or other foulness of the sea which

which cannot be perfectly separated from it by any gentler or less laborious treatment. The sea-salt thus purified, is neither of an acid or alkaline nature; for it makes no effervescence with spirit of vitriol or oil of tartar. 'Tis wonderfully fixed in the fire, much more so than nitre, and will not flow without a violent heat; and then 'tis apt to run thro the pores of the containing vessel. Being calcined with the most intense degree of fire, it neither changes its nature, nor becomes the sharper; but it runs spontaneously in the air, by attracting the moisture thereof. There is this farther remarkable of it, that either directly or indirectly 'tis the only solvent of gold, mercury alone excepted; and powerfully dissolves it, if mixt with spirit of nitre, which is thereby turned into what we call *Aqua regia*, as being the menstruum for the regal metal. It preserves its virtues entire in passing thro' all the stages and circulations of the animal body, where nitre would be considerably changed. Lastly, it defends all the parts, both of animals and vegetables from putrefaction; so that they may be preserved entire by its means for a long series of years. The like properties may also be understood of sal-gem, which appears to be the same kind of salt, tho found in a different form, and dug up in mountains, or mines, far distant from the sea.

P R O C E S S CXXIX.

Exhibiting the preparation of Glauber's Spirit of SEA-SALT.

The process.

1. **T**O a proper quantity of purified sea-salt, dissolved in an equal proportion of fair rain-water, and put into a glass retort, pour, with care to avoid the noxious fumes, a weight of moderately strong oil of vitriol, equal to that of the sea-salt; and as soon as they mix together, a considerable ebullition, heat, and very piercing, prejudicial, and acid fumes will arise; which shew that the sea-salt is now volatilized. After this, apply a capacious receiver to the retort, and first distil off the insipid phlegm, with a gentle heat in sand, till the liquor just begins to rise acid; then pour away the phlegm, firmly lute on the receiver again, and distil with degrees of fire to the highest that can be given in sand: the spirit will rise in white fumes, as that of nitre does in red ones; and when no more liquor will come over, let the vessels cool, and carefully take away the receiver, which will now contain an excellent and genuine spirit of sea-salt*.

Observations
thereon.

2. Tho this spirit of sea-salt be a strong acid, yet it appears to receive nothing at all from the oil of vitriol in the operation; for it per-

* Spirit of salt is generally allowed good and genuine when it appears perfectly transparent, pellucid, or yellowish; when being new, its fumes immediately affect the nose agreeably; but when a year old, it loses its fine acidity and has no scent at all; lastly, when it is of an acid, pungent, saline taste, and neither corrodes nor tinges the cork whereby it is confined. scdly

feetly dissolves gold, especially when obtained pure; which it will not do when mixed with oil of vitriol. The method of purifying it, when the caution of changing the receiver after all the phlegm is come over has not been observed, is to place it in a tall glass, and with a gentle heat exhale the aqueous part which will leave the spirit exceedingly strong and pure. And, what farther proves it the real spirit of salt, if it be joined with fixed alkali, it will again be converted into sea-salt; and if added to a volatile alkali, it becomes mere sal-ammoniac: and therefore where-ever a clean spirit of sea-salt is required, this is the kind that ought to be used, rather than that distilled with bole, which requires earthen vessels, and a strong and naked fire to raise it; the whole process being conducted exactly as in the distillation of spirit of nitre; except that the sea-salt ought to be thorowly decrepitated before it is committed to the retort: by which operation it will be found, that almost the whole body of the neutral, mild, and fixed sea-salt is convertible into white fumes, that condense to an acid, corrosive, and volatile liquor. But if a third or fourth part of bole be not added to the salt before distillation, it will be fused by the fire, and made to pass thro the pores of the glass.

3. The medicinal virtues of this spirit are very considerable, whether it be used internally or externally. Besides the virtues it has in common with sea-salt, and all the acid spirits, it is peculiarly adapted to excite the appetite in persons of a weak or languid stomach. It likewise defends the body from alkaline putrefaction, clears it of viscid phlegm, and is of singular service in the scurvy: *Helmont* also commends it as the best known medicine, for the stone of the bladder and kidneys; a few drops thereof being taken every day in some proper vehicle. Externally applied, 'tis admirable in putting an immediate stop to gangrenes, or mortifications. It appears to be the best corrosive hitherto discovered, for taking off warts and small cancers. I once performed an almost unexpected cure upon a man who had a little cancer in his tongue, only by frequently touching the part with this spirit. But I do not recommend it as a proper remedy in all kinds of cancers; only when they are small, and unaccompanied with a bad habit of body.

*Virtues and
uses of the pro-
duction.*

P R O C E S S CXXX.

Exhibiting the preparation of Glauber's Sal Mirabile of SEA-SALT.

1. **T**AKE the particular, white salt, that, after the preceding process is finished, remains at the bottom of the retort, bruise it, fuse it for some time, at the fire in a crucible, then dissolve it in water, filtre the solution, evaporate it to a pellicle, set it in a cool place, and it will instantly shoot into a beautiful
and

The process.

and strange kind of crystals, of a figure not to be defined, and now commonly called Glauber's sal mirabile of sea-salt.

Old properties of
the production.

2. The figure of these crystals is so uncertain, that they scarce ever appear the same in any two operations, as Mr. Boyle has justly observed, in speaking to the differences he remark'd between salts. And this, he tells us, may well be owing to the quantity or different proportion of acid they contain, or according to the time at which the distillation of the spirit of salt ceased. And if, without a previous calcination, the *caput mortuum* be directly dissolved, filtred, &c. it may be made to afford an incredible variety of crystals, according to the quantity of the acid left behind, whereof it had not been freed by the fire: but if the proportion of the acid be much too great, it may entirely prevent the crystallization; in which case, the solution, and other parts of the operation must be repeated in order to get it out, before it is again exposed to crystallize. M. Tournefort tells us these crystals nearly resemble the strange kind which he observed hang pendulous from the top of a certain cave he met with in his travels. In some of their properties, they come nearly up to tartar of vitriol; but differ from it in others. They have this wonderful property, that being mixed with thrice their own quantity of wine, water, or any other similar liquor, and set at rest in a cool place for twelve, or twenty four hours, the whole liquor will appear to be frozen. And the same effect they produce with the liquor wherein the flesh of animals has been boiled. These several reasons induced Glauber, the first discoverer of this salt, to call it by the name of wonderful; and to give an entire treatise upon the subject thereof; wherein he likewise highly commends it as a menstruum, making it, in a manner, to be almost universal: and indeed its power is admirable in dissolving antimony and other metalline bodies, and extracting tinctures therefrom.

Its medicinal
virtues.

3. This seems to be much the same kind of salt with that the English call by the name of Epsom salt, and of the like medicinal virtues; being indeed, when prepared pure, an excellent purgative; and may be taken in the quantity of an ounce, dissolved in water or other liquor, in the manner of the medicated salt of Tachenius; and when used along with a vehicle disposed to go off by urine, sweat, or insensible perspiration, it appears, more particularly, to promote and increase those discharges: but it ought to be used with discretion, because it is apt to damp, or totally abolish the power of generation.

PROCESS CXXXI.

Exhibiting the Regeneration of SEASALT.

I. **T**O a quantity of Glauber's spirit of sea-salt, obtained as above directed, pour, at several times, so much of the oil of tartar, made per deliquium, as will serve to saturate it, or till the mixture of the two ceases to make any ebullition, or effervescence, and tastes neither acid, nor alkaline, but entirely like the lixivium of sea-salt. The ebullition upon every affusion of the oil of tartar will be very considerable; and care must be had, by repeated affusions, made in small quantities, to hit the exact point of saturation; which being once obtained, the liquor will, upon all trials prove a real and proper lixivium of sea-salt. And if this liquor be filtered, or made pure, and evaporated over a gentle fire to a pellicle, and then exposed to the cold, it will there shoot into actual crystals of sea-salt; as appears plainly by their fixedness at the fire, their taste, figure, and the like; but principally by the power they give to Aquafortis of dissolving gold.

2. Here we see a third, neutral salt produced by the admixture of the violent acid of sea-salt; with a fixed alkali, as was before observed in the regeneration of nitre from its spirit; the regenerated salt participating neither of the acrimony of alkali, nor acid, when the operation is nicely performed, and the due proportion hit. Whence it appears, that in case a very sharp fluid were lodged in the human body, it might be corrected, or have its acrimony destroyed by an opposite salt, without causing any violent disorder; the salt compounded by this mixture being thus made harmless and inoffensive. But in such a case the new salt will partake of the nature of the acid, rather than the alkali; as we formerly observed of nitre, and as appears plainly in the present experiment. Whence we see the justness of that rule, which obtains among the adept, that acids determine alkalies. But tho'tis manifest from this experiment, that sea-salt may actually be regenerated by uniting its spirit to a fixed alkali; yet will it not, according to the doctrine of some chemists, serve to prove in what manner sea-salt, or sal-gem, is originally, by nature, generated in the earth, or sea; because it seems impossible to say from whence such a quantity of fixed alkali should be supplied, as is requisite for this purpose; when not a single grain of it ever appeared to be the production of nature.

Its uses in chemistry, medicine, and natural philosophy.

PROCESS CXXXII.

Exhibiting the extemporaneous production of Sal-ammoniac, with the Spirit of SEA-SALT.

The process.

1. **M**AKE a gradual affusion of the spirit of sea-salt upon a proper quantity of the alkaline spirit of sal-ammoniac, prepared with salt of tartar, till all the ebullition ceases, and the mixture acquires the perfect taste and smell of a solution of sal-ammoniac. The phenomena in the operation will be the same as in the preceding process; and much the same caution is here required. Then this compound liquor being filtered, and evaporated to a pellicle, will form it self into starry flocci, having the scent, taste, odour, and volatility of sal-ammoniac; and being upon all chemical trials the same with that commonly sold in the shops, only purer.

Its uses.

2. Here we see by compounding, as before we found by resolving sal-ammoniac, that it consists of a volatile alkali, joined to a volatilized sea-salt. We cannot however, with safety, from hence conclude, that fossil sal-ammoniac is actually produced in the same manner. This farther advantage we have from our present process, that it shews us how to render any given fixed salt volatile; namely, by first obtaining the spirit thereof, and mixing that spirit with a volatile alkali, as the spirit of urine for instance, then exhaling away the superfluous liquor, as mentioned in the experiment. And thus we can at pleasure turn neutral and alkaline salts into acid ones, and *vice versa*, by distillation, and the making of proper mixtures. We have now gone thro' all the particulars necessary to the chemical knowledge of salts, excepting only the distillation of vitriol, which in strictness, is not a salt, but a semi-metal, and shall therefore be treated as such in its proper place*.

* Nothing of moment seems to have been omitted in this history of salts, unless it be the process for making *Aquaregia*; the menstruum generally used for dissolving gold and antimony. Those who please, may readily prepare this menstruum, by digesting strong spirit of nitre, with a fourth part of its own weight of pulverized sal-ammoniac, in warm sand, till a thorow solution is effected. The glass ought to be large, in proportion to the matter, and the heat but moderate, to prevent any ill effect from the bursting of the glass, or the fumes which are to be avoided. This liquor, when cold, ought to be kept in a glass, with a stopple of the same matter, or one made of wax.

CHEMICAL HISTORY of SULPHUR.

THE next thing to be treated in order, is Sulphur; which comes immediately after salts, and before we proceed to metals, because the first operation to be made upon metals, must be to purify and cleanse them from all heterogeneous bodies, of which sulphur is the chief; and so universally and intimately adheres thereto, that scarce any metal in nature is to be found without it, or can be perfectly freed therefrom.

Sulphur is a fossil body, friable in the cold, fusible, like pitch or bitumen, by a gentle heat, without taking fire of it self, insoluble in water, ardent spirit, and all the known acid liquors; tho it makes a most pernicious suffocating fume with oil of vitriol. It is very inflammable at a naked fire, and burns away in a blue flame; which is the constant nature of sulphur, and of which it can by no art be deprived. In its natural state it is wholly volatile, but proves neither acid nor alkaline upon any chemical experiment; tho a large quantity of acid matter may readily be obtained therefrom. But this no more proves it an acid, than a similar treatment would prove, that nitre and sea-salt are acids, because by the like means they may be converted into such. It is by the chemists, with some shew of reason, called the rosin of the earth; for all the properties which we formerly observed of rosins are likewise to be found in sulphur; excepting only, that it is not of it self, like all vegetable rosins, dissolvable in alcohol of wine. Some chemists have entertained a notion that sulphur may be fixed into metals; but this appears ill grounded: tho it must be confessed that it adheres closely, and seems intimately united to them; which are all brought to their proper form, by being separated and cleansed therefrom*. All the sulphur in use, is supposed to be dug from the earth; and large quantities of it are found in hot subterraneous places where the strong effects of fire are felt. For the other particulars relating to this mineral, we refer to the *Theory*.

* The truth seems to be, that all metals require a certain proportion of sulphur to make them what they are; the purer the less, and the more impure the greater. Metals too far freed of their sulphur, are *calces*; and when they abound too much therewith, brittle, foul, and unfit for working. When by too violent, or too long continued a fusion, the face of any metal happens to be burnt, that is, appears like a crust, and ceases to flow with the body thereof, the way to reduce it, and make it again flow smooth and equable, is to throw into it a due proportion of common sulphur: and when reduced to a mere calx, or glass, it may be made to assume a metalline form again, by fusing it in a sulphureous fire, or a fire of unctuous fuel.

PROCESS CXXXII.

Exhibiting the Sublimation of SULPHUR, or the way of purifying or converting it into Flowers.

The process.

1. **T**AKE any quantity of clean, native sulphur, otherwise called sulphur vivum, reduce it to a fine powder, mix it with an equal or double proportion of pure sand, put the mixture into an iron or earthen retort, carefully lute on the receiver to exclude the air, and in a sand-heat, give a strong degree of fire; upon which the whole body of the sulphur will melt and sublime, or rise in flowers, adhering to the sides of the receiver, and retaining the nature and properties of native sulphur; only sulphur purified, and brought to the form of a meal, or flour.

Its nature and uses.

2. Care must be had in luting the juncture of the subliming vessels, so as to exclude the air, the admission whereof would instantly cause the matter to take fire, and make it suffocating; or unsafe to approach, for fear the vessels should break. This is the common method of purifying native sulphur; which being fused again at the fire, and cast into rolls, is the common sulphur, or roll-brimstone sold in the shops. And if the sublimation were ever so often repeated, the sulphur would undergo no change; but still retain its own nature, without being at all analysed, or separated into its component parts, only rendered volatile. Whence it appears, that sulphur is a semi-volatile substance capable of enduring a strong fire, and a high degree of fusion, without changing its nature; being only purified by this operation, so as to become fitter for chemical and medicinal uses: tho' *Helmont* always preferred the native sulphur to that purified in this manner, as having suffered no alteration from the fire, nor lost its subtile spirit, in which, according to him, resides its wonderful virtue: and on this account he highly commends it as an antipestilential medicine, ordering it to be given with salt and vinegar, and assuring us it was the great remedy of *Hippocrates*, in the cure of the plague. This is certain, that sulphur is an admirable remedy for the itch, and all cutaneous diseases; and may safely be administered in inflammatory or pestilential cases. But some have been so injudicious as to seek for the philosophers stone therein; as if a thing so volatile as we find it in this process, were very capable of being fixed, or transmuted into a pure metalline substance.

PROCESS CXXXIV.

Exhibiting the Analysis of SULPHUR, or the method of making Oleum Sulphuris per campanam.

1. **M**ELT a proper quantity of the flour of sulphur, over a gentle fire, The process in a low, cylindrical, earthen vessel, of three or four inches diameter; when it is thoroughly dissolved, place the containing vessel upon a wide glass dish, in a chimney, and set fire to the melted sulphur, so that its whole upper surface may appear on flame; then place the sulphur under a broad and large glass bell, suspended for the purpose, and first bedewed on the inside, and heated with the vapour of hot water, to prevent its cracking by the heat of the lighted sulphur. This bell is to hang so, that there must be the space of half an inch between its lower surface, and the edge of the vessel containing the burning sulphur, to give a free passage to the air; and if all things are rightly managed, the fumes of the burning sulphur, being now condensed by the sides of the bell, will trickle down, in the form of a penderous, reddish, acid liquor, into the glass dish standing under the mouth of the bell: and this liquor is called by the name of spirit, or oil of sulphur, per campanam. And thus if the operation be duly continued, and the sulphur was exceeding pure, the whole quantity will be resolved into blue flame, and this acid spirit.

2. I have endeavoured to perform this process according to the different directions of all the chemical writers; but always without success, How best performable. till I fell upon the method of M. Homberg; who for this purpose orders a very large bell to be made of a glass cucurbit, by cutting off a large part of its bottom in a circular form, with a diamond; so as to leave a very wide empty space. When this is done, he places the earthen dish, containing the sulphur, upon a clean glazed pan; but with some pieces of glass between to support and raise it above the pan, lest the oil that distills down into it should corrode the bottom of the dish externally, and so become impure. The cucurbit, when cut in this manner, he suspends at such a distance above the pan, as to give free entrance to the air; otherwise the sulphur, which ought to be kept continually flaming would soon be extinguished. And that it may be suspended with the greater convenience, he pastes a slip of linen cloth around the neck of the cucurbit, by means of starch and water; and in this linen makes convenient loop-holes for the string to run thro' that is designed to suspend it, and keep it firm. If during the operation the sulphur should happen to be extinguished, it must again be melted and treated as before. But sometimes when the flame seems almost expiring, the stirring of the matter about will alone recover it. And if it be thus kept stirring, so that the upper crust may be mixed and made to burn with the other matter, the whole body of the sulphur will be consumed, and no fæces remain behind; but if the sulphur were impure, or this caution neglected, there will be found

found, at the end of the operation, a fixed bituminous substance, somewhat of a semi-volatile nature. Whence it is manifest, that pure sulphur consists of an inflammable and uninflammable part, or a perfect oil and an acid liquor, very like pure oil of vitriol: and this gives us the reason why the mixing of any kind of oil, properly so called, with oil of vitriol, forms a sulphur, or bitumen. The operation is made to best advantage in a moist, quiet, and cool place below ground, or when the air is damp and cloudy. The fume which arises therein, ought solicitously to be avoided, as being poisonous to all the animals that have lungs, which it violently constricts, and thereby stops the circulation of the blood, so that it suffocates the creature. The same, however, is wonderfully preventive of fermentation and corruption in natural bodies.

Chemical and
physical uses of
the process, and
production.

3. This spirit has the power of dissolving abundance of metalline and stony substances, and thereby of producing many vitriolic and bituminous bodies. From whence we may easily account for the origin of such kind of bodies in the bowels of the earth. It differs but little from oil of vitriol, except that the latter generally contains some metalline parts; whereas, this appears to be a pure and universal mineral acid. And as this inflammable sulphur is constantly found in vulcanos and fiery mountains, 'tis highly probable that their igneous and suffocating eruptions proceed either from this mineral, or the pyrites, which contains a large proportion of sulphur.

Medicinal vir-
tues and uses
of the produc-
tion.

4. This oil of sulphur is esteemed the best acid we have for medicinal uses; and preferable to oil of vitriol, on account of its purity. 'Tis thought excellent in burning fevers, and all other distempers proceeding from an alkaline cause. *Helmont*, in particular, commends it as a great preserver of health, and tending to procure long life; a single drop thereof being taken, with some proper vehicle, every morning upon an empty stomach.

PROCESS CXXXV.

Exhibiting the manner of Dissolving SULPHUR in fixed alkali.

The process.

1. **T**AKE equal quantities of purified sulphur, and good dry salt of tartar, grind them well together in a mortar, and put the mixture into a crucible; which, being covered with a tile to prevent the firing of the sulphur, is to be set in an open fire, till the matter flows; upon which the sulphur will instantly be dissolved by the salt. Then take out the crucible, and suffer the matter to cool, and it will appear in the form of a red mass of a particular odour; friable, and readily soluble in water, or capable of running by the moisture of the air, or forming an oil of sulphur per deliquium, and never to be reduced to sulphur again.

2. By

2. By this means sulphur is made so perfectly dissolvable in water, tho its use. of it self it obstinately resists it, as thus to become potable, and fit for various uses. This method also furnishes us with a method of purifying metals from their sulphur; which is apt to render them brittle, and unfit for the hammer. Thus if any metal abounding with sulphur, be fused with a proper proportion, as suppose twice its weight, of fixed alkali, or salt of tartar; this salt will attract the sulphur, and thereby become of a red or gold-colour, and rise in the form of dross towards the top of the crucible; leaving the purified metal at the bottom: on which account this salt is, by the purifiers of metals, called a flux. And in the same manner we may presently find whether an ore, or unknown mineral substance, contains any sulphur, and in what quantity. The same experiment, likewise, affords us a key for discovering the cheat of those chemists who put off a tincture of sulphur prepared in this manuer, for the tincture of gold; which it greatly resembles in colour.

PROCESS CXXXVI.

Exhibiting the manner of Dissolving SULPHUR in volatile alkalies.

1. **U**PON a quantity of purified sulphur, reduced to powder, or upon the The process. flowers thereof, pour a suitable proportion of any oily, volatile, alkaline, animal spirit, as that of hartshorn, human blood, or the like; let them stand together in a close vessel for some time, and the spirit will gain a tincture from the sulphur, by dissolving a part thereof, which rises, like golden drops, to the top of the liquor.

2. From this experiment we may learn the action of sulphur in the Its use. body: for if it happens to find a volatile alkali there, it will presently be attracted, absorbed, and at the same time dissolved thereby, so as to stimulate the intestines, and cause them to discharge their contents; the scent whereof will then be exceeding fetid. And this property perhaps it is, that renders it serviceable in the plague, and other distempers proceeding from an alkaline cause. But in those diseases which are owing to an acid in the body, it seems to act no otherwise than by its weight, which may sometimes stimulate, tho its effects, in this case, generally prove insensible.

PRO-

PROCESS CXXXVII.

Exhibiting the solution or tincture of SULPHUR in alcohol, by means of fixed alkali.

The process.

1. **U**PON a quantity of sulphur dissolved in fixed alkali, after the manner of the hundred and thirty fifth process, and reduced to a dry powder, pour a suitable proportion of pure alcohol of wine, and there will instantly be made a fine golden tincture of sulphur, which by standing, even in the cold, will gradually become deeper; and much more so, if the containing glass be shook. When this quantity of alcohol is impregnated with the sulphur, it may be poured off, and fresh put on, till it will no longer tinge it self upon the mineral; and by this means there will be obtained an actual and genuine tincture of sulphur.

Its use in chemistry.

2. Many chemists have denied the possibility of extracting a true tincture of sulphur with spirit of wine; and indeed that spirit, unassisted with fixed alkali, cannot effect it by long digestion. But our present process shews us, that sulphureous bodies, once opened by fixed alkali, may readily be made into a tincture; and allows us to conclude, that whenever a mineral or metal, calcin'd with fixed alkali, gives a deep red tincture with alcohol, this tincture is owing entirely to the sulphur adhering to the metalline or mineral body. Had the Elector of Cologne understood this, he would never have paid so generous a price to that subtle alchemist who put such a tincture upon him for *aurum potable*; tho, the better to carry on the cheat, he actually employed some gold in the preparation, which he could easily recover again. The method it self we have formerly hinted, and in short was this: he took gold, antimony, and salt of tartar, and fused them together; then, after the mass was cold, he poured alcohol upon it, which immediately drew out a tincture, in all respects, like that of our present process; the sulphur of the antimony being here alone dissolved by the menstruum; for which purpose it was previously opened by the salt of tartar; the gold remaining all the while untouch'd. And this is the foundation and origin of all the red tinctures hitherto prepared from metals.

Medicinal use.

3. All the sulphureous tinctures obtained in this manner, are very drying, healing, dissolving, and aperitive; on which account they may properly enough be given in such distempers as proceed from cold, aqueous causes, and where the fluids are mucous or too viscid. Dr. Willis, indeed, commends them in phthisical cases; but they seem too hot and drying for that purpose, especially if an ulcer be actually formed in the lungs.

PROCESS CXXXVIII.

Exhibiting the manner of making Syrup of SULPHUR.

1. **D**issolve of sulphur, incorporated with fixed alkali, after the manner of *The process.* the hundred and thirty fifth process, in about eight or ten times its own weight of fair water; filtre the warm solution, and boil it up to the consistence of a syrup, with an equal, or a double weight of sugar.

2 This experiment shews us a method of rendring sulphur potable; *its uses.* and at the same time instructs us in the nature of the lixiviums to be gained by means of fixed alkali from metals; and the method of purifying ores or metalline glebes. If pure sulphur, without addition, were, for years together, to be digested or boiled in water or alcohol, it would never be dissolved thereby: but if it is first fused with salt of tartar, it readily affords a high tincture, or rich solution, with them. And all the tinctures gained from metalline substances, first fused with fixed alkali, are of this kind; not that the menstruum, as some would have it, draws out the sulphur of the metal; but only dissolves the external sulphur, which is always apt to cleave thereto. In like manner, when any metalline glebe or ore is to be purified, and reduced to the form of metal, the usual way is first to roast or torrefy it, then grind it to powder; and lastly, either to fuse it, as we lately mentioned, with thrice its weight of fixed alkali, which incorporating with the light, sulphureous part of the ore, leaves the heavier metal at the bottom of the crucible; or else, after the manner of the present process, to boil it in a strong lixivium of quick-lime or salt of tartar, which will likewise dissolve away the sulphur from the metalline part.

3. This syrup of sulphur was Dr. Willis's pectoral, or great secret for *Medicinal virtues of the production.* coughs; which he highly commends even in case of the phthisic and ulcerated lungs: but, like the tincture of sulphur before-mentioned, it is very desiccative as well as healing to the body; and therefore seems only proper for this distemper in moist, cold, or phlegmatic habits, or when it proceeds from defluxions, catarrhs, or such kind of causes. I have often used it, however, in these cases, but could never observe any considerable effects it produc'd: which possibly may be owing to the difference of climate, or constitution of the inhabitants, between *England* and *Holland*. But I should never employ it in hot distempers, dry coughs, ulcerated lungs, and asthma's; as believing it, in these cases, very prejudicial. It may, perhaps, be made more pectoral, and fitter for some purposes, by using syrup of hyssop, instead of sugar, in its composition.

P R O C E S S CXXXIX.

Exhibiting the solution of SULPHUR, or the preparation of its Balsam, with expressed oils.

The process.

1. **T**O one part of the flowers of sulphur, put into a large, glazed, earthen pot, add three or four parts of oil-olive, gained by expression, or any other expressed oil whatsoever, and boil them together over a soft fire, for the space of an hour, or till the sulphur, which is apt to remain in fusion at the bottom, be totally dissolved and united with the oil into a red balsam, called by the name of Helmont's balsam of sulphur.

Its uses.

2. Here we see that sulphur is readily dissolvable in gross oils; which shews the general method of preparing the balsams thereof; and gives us another method of separating ores or metalline bodies from their external sulphur. Thus antimony, for instance, being reduced to powder, and boiled in oil, will be freed of its sulphur, which is now formed into a balsam. And this may be sufficient to let us see, that all the balsams gained after the same manner from metals, are no more at bottom than balsam of sulphur; being very improperly called the balsams of the metals from whence they were gained.

Medicinal virtues of the production.

3. This balsam is recommended both for external and internal uses, as being warm and mollifying in case of wounds, sanious ulcers, fistula's, &c. and curative even of ulcers in the lungs. Helmont particularly crys it up in all diseases of the breast. But I cannot at all approve of it as an internal medicine; because it is certainly of a very disagreeable taste, and leaves such a nauseous impression upon the tongue as is hard to be got off again. Besides, the oil it is made of being very gross, it may be apt to cause obstructions in the lungs: and I have frequently found, that upon giving this kind of balsam in phthical cases, the fever and other symptoms have been increased, and the appetite depraved. But as an external remedy, it is doubtless very serviceable in wounds, ulcers, &c. which seems to have given the occasion of its being likewise applied as an internal in similar cases.

P R O C E S S CXL.

Exhibiting the method of dissolving SULPHUR in distilled oils, or of preparing Balsamum Sulphuris terebinthinatum.

The process.

1. **T**O a proper quantity of the flower of sulphur, put into a tall glass, pour four or six times its own weight of fine athereal oil of turpentine, and boil them together for the space of eight hours; during which time a large part of the sulphur will dissolve with an audible noise; but not so readily

readily, nor in so great a quantity, as if it would in an exposed oil; a considerable portion remaining, like melted pitch, at the bottom of the glass, utterly incapable of being intimately joined with the oil. The clear solution, being poured from the undissolved sulphur, is called Balsamum sulphuris terebinthinatum; which, by long standing in the cold, will also let fall some part of the sulphur before suspended therein.

2. We see, therefore, that the gross, smooth, or most unactive oils The doctrine it affords. are more capable of making a ready and thorow solution of sulphur, than the sharp and subtile; so that alcohol, which is an oil exceedingly subtilized, will not touch it at all; whilst it readily unites with the thick, heavy oils, gained by expression, as that of linseed, for instance. Whence we may lay it down as a rule, that this kind of solution is according to the density of the menstruum employed.

3. This balsam being wonderfully hot and penetrating, ought to be used with caution; or only in cold and aqueous cases or constitutions. When Medicinal uses of the production. given internally, it operates with great expedition; as is manifest by the change it presently makes in the colour and scent of the urine and sweat. A few drops thereof, drunk in a glass of wine, will immediately give a scent of violets to the urine. But I prize it more as the product of a chemical experiment, than as a medicine; because we have always some mischief to apprehend in the body from those fat substances which are able to make a solution of sulphur. On which account it is ill judged of some chemists to recommend this balsam, before all other medicines, in the cure of the stone or gravel; tho it must be acknowledged diuretic and aperitive. But if there be any inflammation in the bladder or kidneys, or any tendency to a fever, it may prove very prejudicial; and in contrary circumstances perhaps as serviceable. This is certain, that it may be externally used with much greater safety than internally. It is a good dressing for foul, sanious ulcers, in tendinous or nervous parts of the body; being applied warm. But here also it will prove pernicious in case of inflammation.

4. The different solutions of sulphur are readily convertible into various kinds of balsams, by mixing with them the essential oils of particular vegetables, to take away their natural odour, and give them a new one; from which alteration they generally receive their names. Thus anisated balsam of sulphur is made by adding so much essential oil of aniseeds thereto, as may give it the predominant smell and taste thereof. And the like addition may be made of the oils of amber, cloves, &c. so as to form balsams of specific qualities and virtues. Or the like may be done by originally dissolving the sulphur in proper medicated oils, prepared by infusion, coction, distillation, or otherwise, from suitable ingredients, in the manner of our present process. Ways to vary and improve it.

PROCESS CXLI.

Shewing the method of dissolving Balsam of SULPHUR in alcohol.

The process.

1. **T**O the terebinthinated balsam of sulphur of the preceding process, add thrice its weight of alcohol, and by strongly shaking the containing glass, they will presently mix into an alcoholized balsam of sulphur; a small proportion of the sulphur afterwards falling to the bottom. But by long digesting them together, the sulphur will intimately unite with the alcohol, and the oil of turpentine sink to the bottom of the vessel.

Its use.

2. Hence we are furnished with another method of dissolving sulphur in alcohol; and by that means of drawing sulphureous tinctures with it from antimony, and other semi-metals; namely, by boiling them first in oil to extract their sulphur, which may afterwards, by digestion, be taken up with a pure inflammable spirit.

Medicinal virtues and uses of the production.

3. This balsam is greatly commended in all sanious and purulent ulcers; or where matter ought presently to be discharged, or its afflux to be stopped; as in all wounds of the nerves, tendons, joints and lymphatics. A few drops thereof, applied hot, will dry up the humors, and give strength to the part. It is likewise successfully used in large gun-shot wounds, fistula's, &c. and powerfully prevents gangrenes or mortifications.

PROCESS CXLII.

Exhibiting the preparation of the Soap of SULPHUR.

The process.

1. **I**F, instead of the oil-olive used in the common preparation of soap, the balsam of sulphur prepared either with expressed oil, as in the hundred and thirty-ninth, or oil of turpentine, as in the hundred and fortieth process, be boiled up to a due consistence, with the strong lixivium of salt of tartar, there will be obtained an intolerably fetid and fiery soap.

Its use.

2. These soaps, tho' cried up as an universal medicine by Helmont, who first prepared them, and Starkey, are by much too sharp, caustic, and nauseous for internal use; whence I am inclined to think they neither of them had any experience of their virtues. For my own part, I cannot heartily recommend the internal use of sulphur, in any quantity, after what manner so ever it is prepared. The chemical use, then, of this experiment, is to shew that fossil sulphurs are reducible to soaps.

PROCESS CXLIII.

*Exhibiting the Generation of SULPHUR from oil of vitriol
and oil of turpentine.*

1. **W**ITH a proper quantity of oil of turpentine, put into a cucurbit, care-^{The process.} fully, and by slow degrees, mix an equal weight of strong oil of vitriol; the vessel wherein the mixture is made being first heated and placed in a chimney, to carry up the noxious fumes: a great ebullition, and considerable degree of heat, will ensue upon every affusion, with a copious, red fume, and sometimes even the flame of sulphur. When the whole quantity of oil of vitriol is poured on, and the ebullition ceased, gently distil the mixture in close vessels, and a sand-heat, and there will come over an oil exceedingly like petroleum; a black, pitchy, or bituminous substance remaining at the bottom of the retort, fusible by heat, brittle in the cold, burning away in a blue flame, and both in taste and smell like sulphur. And if this bituminous matter be carefully dried, and urged with a stronger fire, it will sublime into true, yellow, inflammable sulphur; but more fetid than the natural.
2. The mixture of the two oils requires a good deal of caution; for if ^{The Caution} too large a quantity, or more than a few drops, be poured on at once, ^{to be observed} it might endanger the breaking of the vessel, the firing of the liquors, and, by the fumes they afford, the suffocation of the operator; the mephitical exhalations in this operation being near of kin to those of the *Grotta de cani*, not far from *Naples*. The distillation, likewise, requires to be made with care; lest the matter, by blocking up the neck of the retort, should occasion the vessels to burst; or the lute cracking and admitting the air, should set the matter on fire.
3. This experiment does not only succeed with oil of turpentine, but ^{The doctrine} also with any other vegetable oil, or unctuous matter; whence we may ^{affords} draw this general conclusion, that any strong mineral acid, mixing with any fat or unctuous vegetable, will form a bituminous or sulphureous substance. And in this manner probably it is, that sulphureous and bituminous bodies are formed in the earth; the universal mineral acid being sometimes mixed with petroleum, and sublimed in proper caverns by the subterraneous heat. This is certain, that as by resolution we formerly found sulphur divisible by fire into a combustible oil, and an inflammable acid spirit; so now by composition we find it may be made by the joint union of a vegetable oil and a mineral acid.

PROCESS CXLIV.

Exhibiting the Generation of SULPHUR from oil of vitriol and alcohol.

The process.

1. **T**O one part of strong oil of vitriol, put into a warm glass retort, and set under a chimney, carefully, and by small quantities at a time, add thrice its weight of alcohol; and when the heat, ebullition, and noxious fumes occasioned by the mixture are ceased, shake the glass, and distil the liquor with a gentle heat into a capacious receiver; the juncture of the vessels being well closed. Upon this, the whole place will immediately be filled with the sweet scent of the male southernwood, which however is afterwards very suffocating and offensive to the lungs; in the mean time there will come over into the receiver a sweet spirit of vitriol, but of a strong sulphureous suffocating odour; leaving a black, pitchy, bituminous matter behind it, which in every respect appears to be sulphur; and accordingly, by a stronger heat, will sublime into flowers.

The caution it requires.

2. Great caution is to be used in this as well as the former process, to avoid the noxious fumes, which so contract, or otherwise affect the lungs, as to prove suffocative, or cause a violent coughing that cannot in a short time be stopped.

The production what.

3. The liquor that comes over in this process seems to be the sweet spirit of vitriol, or Lully's water, the fragrant whereof is so much talked of by the ancient chemists; for if it be distilled in any considerable quantity, its scent will be diffused all around to a great distance from the house where the operation is performed. Whence it is by some of them said to draw the birds of the air together by its odour.

Use of the process.

4. The operation it self informs us, that a very subtil oil, such as pure alcohol is, may by means of an acid be converted into actual sulphur; which therefore cannot with any colour of reason be expected to contain, or be readily convertible into metal.

PROCESS CXLV.

Exhibiting the preparation of Lac Sulphuris.

The process.

1. **I**F any acid liquor be mixed with the tincture of sulphur, prepared with fixed alkali and alcohol, in the manner of the hundred and thirty seventh process, its red colour will immediately be changed to white; and upon this, a substance will be precipitated to the bottom of the vessel, which when washed in water and dried, is by the chemists called Lac Sulphuris, or the magistery of Sulphur.

2. The

2. The experiment will likewise succeed in an aqueous solution of *Its use.* sulphur, first united by fusion with fixed alkali; and many chemists have strangely pleased themselves with such a preparation, considered as a medicine; imagining that nothing could withstand its force. But the principal use we make of the process, is to shew that all sulphureous fossils, opened by alkalies, or dissolved in sulphureous menstrooms, may presently be turned white, and precipitated by acids. And this is also the case in the red tinctures gained from metalline or other mineral bodies; as particularly in the deep tincture of antimony, which may thus instantly be turned white, and have its sulphur thrown down to the bottom of the containing vessel.

CHEMICAL HISTORY of METALS.

THE treatment of metals ought, in a just and methodical course *Introduction to the history of Metals.* of chemical operations, to precede the treatment of semi-metals, as being much more simple and tractable than they; for semi-metals are a mixture of heterogeneous parts along with such as are truly metalline. And therefore, in order to know what metal they contain, we must first be brought acquainted with metals themselves: an ample description whereof, with all that relates to their purification, and fitting for chemical uses, we have formerly delivered in the second part, or *Apparatus*; to which, therefore, we here once for all refer, to shorten the remaining part of our business, instead of repeating the like account at the head of the separate history of every metal.

CHEMICAL HISTORY of IRON.

WE shall begin our chemical examination of metals with *iron*, be- *Introduction to the history of Iron.* cause this, of all the number, approaches the nearest to a vegetable nature, and is most manageable; as may appear from the facility and readiness wherewith it dissolves, and becomes one with other bodies. And in the same order we shall go on with the rest of the metals, according as they approach nearest to this in their nature, or easy and commodious manner of treatment; which being here observed once for all, will save us the trouble of frequent repetitions, that might otherwise be necessary to keep the reader in mind that we still proceed in the same geometrical method hitherto followed.

PROCESS CXLVI.

*Exhibiting the preparation of the Vitriol of IRON.**The process.*

1. **U**PON a quantity of clean and bright filings of iron, placed in a convenient glass vessel, first made hot, to avoid its breaking, pour an equal or a double weight of strong oil of vitriol, and no remarkable effervescence or solution will ensue; but proceed to add gradually about three or four times as much warm water as there were filings of iron employed, and immediately a strong ebullition and a considerable heat will arise, together with a smell of sulphur or garlick, like that observable in mines, or particular mineral waters; and thus a perfect dissolution of the metal may gradually be effected. About which time, the liquor is not acid, but of a sweet, vitriolic, or styptic taste; the sharpness of the oil of vitriol being quite destroyed by the metal. But if any considerable quantity of the iron should remain undissolved at the bottom, a few more drops of oil of vitriol may be added; and on the other hand, if the solution should be total, it will be proper to add a little more filings, to prevent any predominating acidity of the oil of vitriol. When the solution is thus nicely adjusted, the green-coloured liquor is to be filtered and evaporated to a pellicle, over a gentle fire; after which, being set in the cold, it will shoot to the bottom and sides of the vessel, in the form of green, transparent crystals, called by the name of sugar, magistery, salt, or vitriol of iron; being fusible at the fire, and perfectly dissolvable in water.

Its nature and use.

2. This is the general method of rendering metals potable, or calcining them by moisture, as it is called, and gaining their vitriols; which appear to be no other than the metals themselves, united with a certain proportion of acid and water, and thereby formed into transparent crystals. And it is remarkable, that they all, in dissolving, smell strong of sulphur: from whence we may have a criterion for judging of the success of mineral waters, when drank medicinally; for if upon taking any quantity of the chalybeate water of a medicinal spring, the eructations should have the smell of sulphur, it will be a plain indication that there is some acid humor in the body, which makes a solution, or mixes with the iron in the water; and consequently, that the drinking of such water is likely to cure the distempers producible by such an acid. It is also very remarkable, that if this process be performed in a tall glass, the fumes which ascend to the mouth thereof will readily take fire at a candle, and go off like gun-powder, with flame and explosion.

Virtues and uses of the production.

3. The vitriol of our present process is the basis of all the black kinds of ink, and esteemed an excellent diuretic and aperitive medicine, and a great destroyer of worms in the first passages. Its medicinal virtues it has partly from the metal, and partly from the acid of the vitriol. When taken in a considerable dose, it proves purgative, and if in a larger vomitive. Dissolved in a large proportion of fair water,

as in the quantity of a grain to a pint, it so perfectly resembles those of the *Spaw*, as scarce at all to be distinguished from them, especially if mixed with a drop, or less, of oil of vitriol. But if it be mixed in too large a quantity with the blood, 'tis apt to coagulate and turn it black; as also to render the small fibres of the body dry and crispy: on which account it is an excellent styptic, corroborating, and desiccative medicine, when properly used. But if it be made with too large a proportion of the acid, it may become prejudicial when used internally. In some cases we find that crude iron is a safer, and more effectual medicine, than when joined with acids; as particularly in the green-sickness and the like. *Helmont* observes, that all such peripneumonical persons as make use of vitriolic waters, die; the vitriol turning to oaker in their bodies; and the water taken along with it coming away clear: oaker being nothing else but the calx of iron. Hence we may learn, that when any chalybeate waters deposite a yellow sediment, they are no longer fit for use; as having now lost their most medicinal part.

PROCESS CXLVII.

Exhibiting the preparation of Ludovicus's Tincture, or potable Vitriol of IRON.

1. **T**AKE equal quantities of the pure vitriol of iron, and crystal tartar, reduced to powder; boil them together in an open glazed vessel, with twenty times their own quantity of fair water, to the consistence of honey; then put this thick mass into a tall glass, and pour upon it about twelve times its weight of Spirit of wine, once rectified, and boil them together for four and twenty hours, or longer, and there will appear on the top a red tincture, which, being decanted from the feces, is Ludovicus's tincture, or potable vitriol of iron. The process.

2. The experiment shews us a method of uniting vegetable with metalline salts; in which, when the metalline salt is obtained by means of an acid, it is requisite that the vegetable salt should likewise be acid. Its use.

3. This tincture of iron, which has its name from *Daniel Ludovicus*, who describes it in his treatise of pharmacy accommodated to the modern practice, is, we see, a solution of the vitriol of iron, and the body of tartar, in spirit of wine; and therefore an admirable stimulating, aperitive, detergent, and relaxing medicine; good to cleanse the first passages, and to destroy worms therein; being taken in the quantity of sixty drops, with a glass of French wine, upon an empty stomach, and the dose repeated at the distance of an hour or more. It is likewise serviceable in too great a laxity of the fibres, in the scurvy, a beginning dropsy, weakness in children, and particularly in the rickets. It may also be used with safety and advantage in leucophlegmatic habits. Virtues and uses of the preparation.

the green-sickness, hysterical and hypochondriacal disorders, and the various kinds or degrees of the jaundice. In strong constitutions, it may be taken in the quantity of two or three drams for a dose; drinking some convenient liquor at the distance of half an hour after it. And thus it may be continued for two or three weeks together, the patient using proper exercise, as riding, walking, or the like; by which means it will be made to act as a purgative, and turn the excrements black. And it has this advantage to recommend it, that it is not apt to be precipitated into an astringent calx, or crocus in the body. In short, it may be used to advantage in all those cases where the preparations of iron are proper. The best way of preserving it for this purpose, is to keep it upon its own faces, and pour it off from them by a gentle inclination of the vessel, at the time of using it; because, by standing thus, it daily dissolves more of the metal lodged in the faces, so that the older it is the better it becomes. It is a caution proper to be observed during the time it is used, to refrain from taking alkaline spirits, as spirit of hartshorn, or the like, which might prevent the effect thereof.

P R O C E S S CXLVIII.

Exhibiting the reduction of the Vitriol of IRON to a Calx or Crocus; or the preparation of Crocus Martis astringens.

The process.

1. **T**AKE any quantity of vitriol of iron, gently dried and reduced to powder; put it into a clean crucible, and expose it to a soft fire, that only the aqueous part thereof may exhale; upon which the vitriol will lose its green colour, and begin to grow opaque and white; and, being removed from the fire, and preserved in this state, it is called the white calx or powder of iron. Upon increasing the heat, the matter will fuse, and, when cold, turn to a solid, greyish mass; which is likewise called iron, or the vitriol of iron, calcined to whiteness. Increase the fire again, and keep the matter stirring till it entirely ceases to yield any fumes at all; the lighter acid it self being hereby driven off, it will now be reduced to a perfectly dry, red powder, called the red calx of iron, or Crocus Martis astringens.

Its nature.

2. The production of this process is likewise called by the Arabic word *Colcothar*, which signifies the same with red calx, being the most violent astringent obtainable from iron; a portion of the heavier acid of the oil of vitriol still remaining united to it, notwithstanding the strong fire that acted upon it in the operation; from whence proceeds its great stypticity. But if the calcination be very long continued, with a violent fire, so as to drive off all the acid parts adhering to the matter, it will at length be reduced to iron again.

Uses.

3. From hence we see, that metals brought by solution, or liquid calcination, as 'tis called, into the form of vitriols, are fusible with a small degree

degree of heat; when, losing their aqueous parts, they at the same time lose their transparency, and become white or grey. Whence it may plausibly enough be conjectured, that the transparency of such crystals depends upon the water they contain; or that they actually require a certain quantity of aqueous matter to make them what they are. This likewise furnishes us with a method of reducing metals to powder, and afterwards of converting that powder to metal again, by means of nothing but heat and acid. And as in this operation, the longer the matter is detained in the fire, whilst any acid remains mixed therewith, the redder and stronger it becomes; this shews us how bricks ought to be managed in the kiln, to make them durable, and give them the colour most pleasing to the eye; for 'tis the iron they contain that makes them turn red in the burning. Our process, likewise, lets us into the nature and generation of the rust of metals; for these being exposed to the action of the air, and the acid particles which continually float therein, their surface will necessarily be corroded by them, and turned into a vitriolic substance; which afterwards, by the action of the sun, or of the warm air, being deprived of its acid, a calx or rust is of course formed upon the surface of the metal.

4. This colcothar, or calx of vitriol thus obtained, is of a wonderful styptic virtue, and will instantly stop all kinds of hæmorrhages; being applied, upon a little cotton, to the mouth of the ruptured vessel, which it immediately purges up, coagulates the blood in contact with it, and strengthens the part. And on this account it is successfully used in sanious ulcers, attended with a large flux of matter, or fungous flesh; being mixed, in a moderate proportion, along with other materials.

Medicinal virtues and uses of the production.

PROCESS CXLIX.

Exhibiting the method of running IRON into oil; or of preparing Oleum Martis, per deliquium.

1. **E**XPOSE the red calx of iron, in an open glass dish, to the moist, external air, and it will run per deliquium into a gross, thick, unctuous, and exceeding red liquor, or kind of oil, consisting of the acid of vitriol, the body, of iron, and the aqueous particles of the air. *The process.*

2. This is a general method of obtaining the oils of metals, or of converting their substance into what we commonly call by the name of oil; the rationale whereof, tho it may at first appear very difficult to assign, is no other than this. The most fixed and dry part of the acid of the oil of vitriol, remaining in the calx of the metal, being no less attractive of moisture than the fixed alkali of vegetables, readily imbibes the aqueous humidity of the air, by which it is dissolved, and made again to act as a menstruum upon the metalline part of the calx. But as the air contains numerous other particles, as well as such as are aqueous,

Its rationale.

aqueous, those also sometimes mixing with the calces of metals thus exposed, will effect surprizing alterations therein, perfectly change their nature, and make them volatile; especially if the operation be frequently repeated, by drying the solution, and exposing the powder again to the action of the air, which thus greatly opens and volatilizes the body thereof.

*Virtues of the
production.*

3. This oil is a greater styptic, escharotic, and astringent, than the calx of iron it self, prepared in the manner of the preceding process; and may be used much after the same way, to answer the same purposes.

PROCESS CL.

Exhibiting the preparation of Basil Valentine's golden Tincture of IRON, with the dulcified spirit of sea-salt.

The process.

1. **I**F upon the oil of the preceding process, again reduced by inspissation to a calx, or the red calx or crocus of vitriol per se, three or four times its quantity of the sweet spirit of sea-salt* be digested for a while, in a tall glass, a golden or true metalline tincture will thereby be produced; the calx it self remaining undissolved at the bottom.

Its nature.

2. This tincture is exceeding rich in the virtues of iron; on which account, it is said by Tachenius to contain the true sulphureous soul of that metal. The smallest proportion will make a black, atramentous liquor with the tincture of galls; which shews how richly it is impregnated with iron: yet, which is strange, almost the whole body of the metal remains untouched by the menstruum. Basil Valentine, the author of this tincture, who has treated largely thereof, observes that the astringent crocus of iron is totally dissolvable in strong spirit of sea-salt; but gives out only its soul in the dulcified kind of that spirit. This is certain, that whatever be the tinging matter, a gold-coloured tincture is actually produced: and in the same manner a tincture may be drawn from gold, first dissolved, reduced to a vitriol, and calcined; the noble metal losing nothing but its colour in the operation. And one might be tempted to believe, that this golden tincture of iron was really the *aurum potabile* of the antient chemists; of which they write in this concealed manner. "Join me to my sister, and the effect of our conjunction will be a green offspring, a hermaphroditical stone, of which, by means of salt, may be made a golden tincture, or potable gold." Which seems plainly to denote the formation of green vitriol from

* The sweet spirit, as it is called, of sea-salt, is prepared with spirit of sea-salt, in the same manner as the sweet spirit of nitre is from strong spirit of nitre; viz. by mingling and digesting, or distilling it with spirit of wine, in the manner of the hundred and twenty-fourth process.

iron and oil of vitriol, which vitriol, with spirit of salt, affords us the tincture of our present process.

3. This golden tincture of iron has great medicinal virtues; a few drops of it being taken upon an empty stomach, in a glass of Spanish wine, has wonderful effects in cases of worms, and weak viscera. It strengthens a weak stomach, gives tenacity to the relaxed fibres, cleanses the *prima via*; and when the body is languid and unactive, acts powerfully as a stimulus, and quickens the motion of all its parts: scarce any thing in nature being more friendly to the human body, more conservative of all its powers than iron, or more preventive of the diseases whereto 'tis subject.

P R O C E S S C L I.

Exhibiting the Solution or Tincture of IRON in Rhenish wine.

1. **U**PON a parcel of clean and bright filings of iron, pour about twenty times their own weight of good Rhenish wine, and boil them gently together, in a tall glass, till they communicate a black tincture, and the wine acquires a sweetish styptic taste, which is then to be poured off clear, and filtered for use.

2. When the tincture is once poured off from the undissolved part at the bottom, if fresh wine be put on, and the process repeated in the same manner as before, the menstruum will not now be so much impregnated as the former: whence this wine extracts a tincture without actually dissolving the metal. The like tincture may also be obtained by letting the menstruum stand upon the filings, in the cold, for the space of three or four weeks, the containing vessel being shook between whiles; or till the tincture becomes sufficiently black and rich.

3. This process shews, that iron is of such a nature as readily to join it self with the mildest vegetable liquors; and being thus divided into exceeding small parts, and intimately united with them, it is no wonder if we find this metal in the bodies of plants, animals, and minerals; as it has lately, by particular experiments, been discovered in the ashes of such bodies.

4. The present tincture is the best and most efficacious medicine of all those obtained from iron; being almost infallible in all those diseases which proceed from mere laxity of the fibres, or coldness, sluggishness, or inactivity of the juices. In effect, it will actually cure all the distempers that are curable by chalybeates. It may be taken in the quantity of half an ounce for a dose, twice or thrice in the day, according to the strength of the patient, at such times as the stomach is most empty. I have my self cured many desperate cases by means of this single remedy; and indeed it is capable of affording any man a comfortable subsistence, if it were handsomely and judiciously disguised, as perhaps it might be with a proper colouring, aromatics, and some

Processes upon Fossils.

some saccharine substance, to render it pleasant and agreeable. This caution, however, must go along with it, that in case of hard swellings, scirrhusities, or predominant acid, it will rather prove hurtful than of service.

PROCESS CLII.

Exhibiting the Solution or Tincture of IRON in small distilled Vinegar.

The process.

1. **I**F instead of the Rhenish wine used in the preceding process, twelve parts of small distilled vinegar be poured upon one of the clean and bright filings of iron, and they be boiled together for some hours, there will be obtained a rich, blood-red tincture, highly impregnated with the sweet, styptic, nauseous taste of the metal.

Its nature.

2. In neither of these two last processes is there a perfect dissolution made of the iron, at all like what is effected by oil of vitriol; tho the spirit of vinegar operates much more powerfully than the Rhenish wine upon it.

Medicinal virtues of the production.

3. The medicinal virtues of this tincture are nearly the same with those of the tincture made with Rhenish wine, but considerably stronger; so that twenty drops of this will answer to half an ounce of the other. It is an admirable remedy for the rickets, as also against viscid phlegm and worms in the bodies of children, operating without causing any disorder; provided they be first purged with scammony and mercury. It may be fitted for this purpose by being boiled up into a syrup with sugar, or mixed and given with any proper syrup, boiled to a high consistence. A few drops of this medicine taken every day in this manner, for some continuance, may prove very beneficial to young children; and recover them, when grown emaciated, pale, and feeble, to a florid colour and strength of limbs. The same medicine is also of excellent service in the disorders proceeding from a suppression of the menses; being taken in the quantity of a dram, once a day, upon an empty stomach.

PROCESS CLIII.

Exhibiting the Sublimation, Volatilization, and Solution of IRON, with sal-ammoniac.

The process.

1. **T**AKE equal quantities of new and bright filings of iron and sal-ammoniac, and grind them together in a glass mortar for a considerable time, the longer the better, till they are reduced to fine powder; then put this powder into a coated retort, fit on a proper receiver, and sublime the mixture, with a
due

due degree of heat in a sand-furnace. The first thing that comes over will be a fiery alkaline spirit, sharp, volatile, pungent, and almost suffocating, not unlike spirit of sal-ammoniac prepared with quick-lime. After this, white fumes will rise and concrete into flowers of sal-ammoniac; and, upon considerably increasing the fire, into gleses of various colours, containing a large portion of the body of the metal; whence they are called flowers of iron. And the operation being continued, with this degree of fire, till nothing farther will come over, there remains, at the bottom of the retort, part of the substance of the iron, so opened and absolutely changed by the sal-ammoniac, that when exposed to the air it will swell, heave, grow spongy, almost fall into fermentation, and at length run per deliquium into a kind of oil.

2. The strong, volatile, alkaline spirit, seems, on this account to rise first in the operation, that the acid of the sea-salt in the sal-ammoniac being converted to acid, is forcibly attracted by the iron, which appears to be a kind of magnet with respect to acids; so that the alkaline part is left at liberty to go up with the first degree of heat. And hence we have a general method of reducing all metals to flowers; for sublimation with sal-ammoniac has the greatest power of volatilizing, opening, and dissolving fixed metalline bodies. Whence this operation is called the chemical pestle; as effecting a more perfect solution of metals than any other method. On the same account sal-ammoniac is called the key or opener, and by some the white eagle, which bears away the parts of metals with its wings. This process, likewise, shews us another way to obtain the oil of metals *per deliquium*, as also their tinctures; for the remainder of our present process, will, by digestion, make an excellent metalline tincture with spirit of wine; and, as well as the flowers, run into a liquor in the open air. In like manner may the vitriols of metals, reduced to a calx, be more easily sublimed into flowers. And these flowers being dissolved in water, will thereby be separated from the salt, and left in their utmost degree of purity and perfection; in which state they are fit for the more curious purposes of chemistry or medicine. And according to *Paracelsus*, all metals are in a state of death, till dissolved by a corroding menstruum, and afterwards revived and quickned by this kind of sublimation.

3. The flowers of iron, obtained by this process, are of a sweetish, styptic, nauseous, oily taste, but of a very strengthening and aperitive virtue, when used internally; tho they are apt to prove emetic or nauseous upon the stomach. They receive their virtues from the sal-ammoniac, in conjunction with iron; whereby its body is so opened as to become of very great efficacy in the cure of the rickets, and capable of performing all, and perhaps more than Mr. Boyle has said of the *Ens Veneris*. Taken in the quantity of a few grains, this medicine powerfully stimulates the first passages, and proves of very great service in all distempers arising from flaccidity of the fibres.

Its nature and uses.

Medicinal virtues of the production.

PROCESS CLIV.

Exhibiting the Calcination of IRON, or the preparation of Crocus Martis aperiens, with Sulphur.

The process.

1. **G**RIND together equal quantities of clean and bright filings of iron, and flowers of sulphur, into a fine, brown powder; put the mixture into a strong, earthen crucible, which being but lightly covered and placed in the fire, the sulphur in burning, will, by its acid, then set free, perfectly dissolve the iron, and leave it in the form of a calx or powder; called by the name of Crocus Martis aperiens, or Chalybs cum Sulphure paratus.

Varied.

2. The same effect may be produced by grinding the iron filings and sulphur together, and afterwards reducing them to a paste with water; for this paste being suffered to lie for about an hour in an earthen vessel, will conceive a great degree of heat, which spontaneously ceasing, leaves the iron converted into a crocus. Which experiment may serve to explain the phenomena of earth-quakes, and subterraneous fires. For if such a mixture should, as it easily may, happen to be made in the bowels of the earth, it would grow hot, take fire, and violently tear up whatever opposes its expansion.

Its use.

3. This process, which exhibits the method of dry calcination, or Dr. Willis's way of preparing iron for medicinal uses, gives us a general rule for calcining all kinds of metals, or reducing them to powder, by the assistance of sulphur. But the iron thus calcined seems to be destroyed; for it cannot, by the fire, be reduced to metal again. And as to the medicinal virtues of this preparation, I have always found crude iron more effectual.

CHEMICAL HISTORY of LEAD.

PROCESS CLV.

Exhibiting the Solution of LEAD, or its conversion into Ceruse by the fumes of vinegar.

The process.

1. **B**EAT pure lead into thin plates, and suspend them, by a proper contrivance, in the head of a glass alembic, wherein vinegar is to be distilled, or in any other place, so that they may be penetrated by the fumes of that liquor, which will thus corrode the metal, and turn its surface into a
white,

white, crusty matter, or ceruse, and afterwards drop down or distil into a sweetish, saccharine liquor, without any acidity. This white, crusty matter being beat or scraped off from the plates, they may be again exposed to the vapour of vinegar in the same manner, and afterwards scraped or brushed as before, till, by repeated operations, the body of the lead is thus wholly dissolved, or converted into ceruse, or the common white lead of the shops; which need only be dried, and reduced to a very white powder, to render it insipid, or fit it for use.

2. This ceruse is nothing more than the calx of lead, made by the acid of the vinegar corroding the metal; and may as justly be called the rust of lead, as verdigrease is the rust of copper, or *crocus Martis* the rust of iron; all of them being the respective metals themselves corroded by an acid spirit, that is afterwards totally or in part exhaled. Whence we see how easy of solution the body of lead is, as yielding to a mild, vegetable acid; from which it also parts as easily. Its nature.

3. Ceruse is an useful medicine, being a great dryer and absorbent, when externally applied; but of a slow, poisonous nature, when admitted, in any quantity, into the body. It has wonderful virtues in drying up all running sores, or draining sanious ulcers; especially where the matter they discharge is acid or saline. On the same account it is serviceable in case of moist and inflamed eyes; especially being applied in a dry form thereto. But in all disorders proceeding from an alkaline cause, as the plague, certain kinds of fevers, &c. it is highly prejudicial; and indeed ought scarce at all to be given as an internal medicine, tho in ever so small a dose. The miserable people who for gain daily assist in the preparation of this commodity, run a great hazard of their lives, and seldom hold out for more than four years: they usually, before that time, become phthical, and dye of an incurable consumption. And this might give occasion to the notion, that *Saturn*, the chemical name for lead, destroyed his children; as it does, the baser metals upon the test. What some time since happened in *Germany*, gives a sad proof of the poisonous quality of this metal: the avarice of some vintners having induced them to take off the too great acidity of their *Rhenish* wine by means of white lead, which it does to great perfection, those that afterwards drank of that wine, who were to the number of above a thousand men, fell into a miserable tabes, and died; which occasioned this practice, for the future, to be made a capital crime. This preparation is likewise very pernicious, when long used as a fucus for the face. Indeed it gives a beautiful white for some time; but afterwards brings on an odious paleness, quite destroys the natural colour, and sometimes, by long use, brings on asthmatical or phthical disorders, and proves actually mortal. Nature and uses of the production.

PROCESS CLVI.

Exhibiting the Calcination of LEAD, or its reduction to Minium, or red-Lead.

The process.

1. **M**E**L**T a quantity of lead in a wide iron or unglazed earthen vessel, and at first the face of the metal will appear perfectly smooth and polite, but will afterwards grow dull, opake, and contract a pellicle or crust; which being taken off with an iron ladle, a new pellicle will be generated, and cover the surface of the metal; and this being taken off as before, new pellicles will arise; and thus, by continuing the operation, the whole body of the lead may be converted into the like calx. If now this calx be put into a larger vessel, exposed to a violent fire, and there kept continually stirring with an iron rod, it will gradually change its colour to grey, brown, and yellow; and at length, by the farther action of the fire, wherein it is to be detained for several hours, appear in the form of a vivid red calx, or powder, called by the name of minium, red-lead, or cinnabar of lead, and, improperly, litharge.

Its effects.

2. It is very remarkable in this operation, that the metal continually gains in weight as it changes its colour, so that when turned to minium, it acquires no less than a twentieth part; that is, if nineteen ounces of lead were to be treated in this manner, the red-lead would weigh twenty. This great increase of weight has generally been thought owing to the fire, fixed by the operation in the body of the lead. And Sir Isaac Newton conceives, that the red colour of the minium is owing to the fire thus concentrated or lodged in the metal. But I cannot subscribe to this opinion, without distinguishing between fire and fuel. I have already proved, and experimentally shewn, in my public lectures, that fire is destitute of weight; and consequently this increase of gravity in the lead cannot be owing to fire, strictly and properly so called; but perhaps it may to the parts of the fuel employed in the operation. This increase of gravity is the more remarkable, because the metal always affords a considerable fume in the operation; whence one would expect it should lose of its weight.

Nature of the production.

3. Red-lead differs from litharge, in that the former is made *per se*, as in the present experiment, without mixing with other metals; whereas litharge is a frothy matter, that adheres to the sides of the test, floats on the surface of lead when fused or cupelled with the nobler metals, and is therefore a more imperfect or undigested minium, mixed with the frothy matter of silver or gold, and of a paler colour than red-lead; and accordingly it is called litharge of gold or silver, as it is obtained or thrown off in purifying those metals. Either kind is, however, capable, by violent ignition, of being brought into the form of minium.

4. It was minium, thus prepared, wherewith the Roman and Grecian ladies tinged their nails and faces of a red colour; as we learn from Plautus and other antient authors. But being of a pernicious nature, it ought to be used with prudence. Externally applied, it has much the same virtues with ceruse. It perfectly dissolves in linseed oil, or oil-olive, by coction; and thus makes *deminium*, which is an excellent plaister for chirurgeons, and one of the best remedies in use for the gout; especially if it be made with wax alone instead of oil, or other unctuous bodies.

PROCESS CLVII.

Exhibiting the Solution of LEAD in distilled vinegar, or the preparation of the metalline Lac Virginal.

1. UPON a proper quantity of crude lead, lead-ore, minium, ceruse, litharge, calx, or spume of lead, put into a tall glass, pour twenty times its own quantity of spirit of vinegar, and let them boil together for four and twenty hours, the vessel being shook between whiles; then, whilst the liquor is hot, filtre it thro' paper, or suffer it to settle, and pour off the clear by inclination, and it will be a solution, of a nauseous, saccharine sweetness, without any acidity, called in the shops vinegar of litharge, but by the chemists metalline Lac Virginal. And if fresh spirit of vinegar be poured to the faces, and the operation be repeated, the whole body of the lead may, by degrees, be dissolved into the like liquor.

2. If the solution be filtred, it ought to be filtred hot, because it will scarce pass the pores of the paper when cold. It is called vinegar of litharge in the shops, only because they usually prepare it with litharge instead of lead.

3. This process furnishes us with another method of reducing metals to oil; for if the clarified solution it affords be evaporated to the consistence of honey, fresh spirit of vinegar be poured thereon, the matter be again inspissed, and the operation repeated as before for a number of times, there will be obtained the ponderous oil of lead, which is exceeding difficult to dry at the fire. And this shews us, that metals are reducible to oil, by intimately impregnating their substance with acid: which also appears to be the case when they are run to oil *per deliquium*.

4. This solution of lead is greatly commended, as an external, in case of stubborn inflammations, and old, inveterate ulcers; and chirurgeons frequently use it in phlegmons, and erysipelatous cases. Being infused with an equal quantity of oil of roses, it makes a noble white balsam for these purposes, called by the name of *Unguentum Nutritum*; but it is actually poisonous when given internally. It gives a beautiful whiteness to the skin; but is a very noxious fucus, as causing violent disorders

ders in the lungs, pthifical and asthmatical complaints, or throwing the person who uses it into a pulmonic consumption. I have my self known some young ladies who killed themselves by frequently employing it as a wash. In like manner, three sisters at the *Hague* died miserably tabid, by endeavouring with it to change the colour of their hair from red to black. And indeed those who deal much with lead, in what form soever, are seldom long-lived.

P R O C E S S CLVIII.

Exhibiting the Solution of LEAD in distilled vinegar, or the method of obtaining its Vitriol or Sugar.

The process.

1. **E**Vaporate the solution, or metalline *Lac Virginale*, of the preceding process, to the consistence of honey, and again let it down with fresh and strong spirit of vinegar; afterwards exhale it away again to a pellicle, or almost to dryness; then set it in a cool place, and it will concrete into a soft, white mass, or salt, of a saccharine taste: on which account 'tis called sugar of lead, as it is also the vitriol or magistery thereof. (2.) If this vitriol, or sugar of lead, be again perfectly dissolved in spirit of vinegar, and afterwards inspissated to the consistence of oil, or till a pellicle appears on its surface, and be set again to shoot in the cold, it will form it self into small and flat quadrangular glebes, or beautiful crystals, not unlike to sugar-candy. (3.) Repeat this operation several times successively, and at length you will have an oil of lead, that can neither readily run into crystals, nor dry at the fire. (4.) Again, if this oil of lead, thus frequently impregnated afresh, be, by a long continued and gentle heat, brought to dryness, it will thereby be turned into a spongy mass; which, in many of its natural properties or characters, resembles silver. (5.) Lastly, dissolve this mass again in spirit of vinegar, and evaporate it to the thickness of oil; after which, being set to shoot, it will afford the most beautiful crystals that can by any means be obtained from lead.

Observations
thereon.

2. It is observable, that by the evaporation of the solution in this process, 'tis only an aqueous, not an acid vapour that flies off; which being caught and condensed, turns to an almost insipid water, but something nauseous. And accordingly, if the vitriol, when perfectly formed, be dissolved in water, it will again afford the *Lac virginale*. The oil obtained in the present process, is called the incrated oil of lead; because it flows or remains fluid like wax at the fire. And after the same manner may several other metals be reduced to a like kind of oil.

4. *If. Hollandus* imagined, that the philosophers stone, and afterwards silver, was obtainable from lead treated in the manner of this process. Indeed the oil here procured, being poured out of one vessel into another, does seem to run in silver threads. But the operation is excessively tedious; for the solution must be several times repeated, and the exhalation very gradually made, before the experiment will succeed. Another

ther author has mentioned some curious particulars of this liquor, in the philosophical transactions of London, but conceals his process.

4. The medicinal virtues of *Saccharum Saturni*, or the vitriol of lead, are these: it is a very powerful styptic, presently coagulating the blood, and constringing the mouths of the bleeding vessels. It is good against inflammations; being dissolved in water, and used by way of a fomentation. And in many other respects it will answer the intentions of the physician or chirurgeon, used as an external: but I cannot imagine it safe to give it, as some do, internally. Almost all the modern physicians, I know, scruple not to administer it in intermitting fevers, and other distempers; but with what success they best can tell. With me it stands in the catalogue of poisons. And tho it may cure the fever, it is apt to leave a worse disorder behind it. This is certain, if it meets with an alkali in the body, it will thereby be turned to a calx, or ceruse, which all acknowledge to be poisonous; being only kept in a saline form by means of the acid of the vinegar. And accordingly, I have observed several persons to complain of a weight at their stomach, loss of appetite, impotency, and several other disorders from the internal use thereof: and indeed it has at length thrown them into a lingering consumption. The *Italians* are well acquainted with these effects of this preparation; and employ it when they desire to be slowly revenged of their enemy. A famous *Italian* physician once told me, that no medicine was used by the monks with such great success as this, for extinguishing all desires to venery, which kind of appetite it infallibly destroys.

Medicinal virtues of the production.

PROCESS CLIX.

Exhibiting the Solution of LEAD, or the method of procuring its Vitriol with small Aqua fortis.

1. **T**O a proper quantity of crude lead, ceruse, minium, or litharge, put into a tall glass, pour an equal, or double weight of spirit of nitre, or Aqua fortis, which being diluted with ten or twelve times its own quantity of fair water, will presently dissolve the lead with an audible noise. Then directly filtre the solution, and it will become a perfectly transparent liquor, of a nauseous, saccharine sweetness, containing the whole body of the metal. And this solution being evaporated, and treated in the manner of the preceding process, will exhibit the same phenomena, and afford another vitriol of Lead.

The process.

2. The productions of this process are much the same with those of the foregoing; the oil and the vitriol obtained by it having the like virtues, but stronger than the former. The crystals, however, of the present process, are of an elegant and singular structure, different from all other kinds of vitriol; being, if the exhalation was gentle and gradual, ponderous, white, sweet, beautiful, inflammable like nitre, and crackling

Its effects.

ling in the fire more than any other known salt. With a strong heat they will fume, part with their acid, and be reduced to a calx. By this process, also, the sugar of lead is obtainable with greater expedition, and to more advantage than with vinegar. And hence we may learn, that lead is easily dissolvable in any kind of acid; and that it constantly acquires a saccharine sweetness thereby. But then the acid must not be too strong, or have its salts wedged too close together; for strong spirit of nitre will scarce act at all upon this metal, till the salt thereof is dissolved, or set free by the admixture of water. It is likewise very observable, how attractive all metals are of acid, or how readily their texture is dissolved, and their tastes varied thereby. Thus the solutions of insipid lead and iron, we have found taste differently nauseous, sweet, austere, or vitriolic, whilst that of silver is exceedingly bitter.

PROCESS CLX.

Exhibiting the preparation of the Balsam of LEAD, with Oil of turpentine.

The process.

1. **U**PON any quantity of the dry vitriol, or calx of lead, put into a tall glass, pour about four or five times its weight, more or less, according as the balsam is desired thick, or liquid, of oil of turpentine; and boil them together, for some hours, till the whole body of the metal is perfectly dissolved into a thickish substance, which is the genuine or metalline balsam of lead.

Its use.

2. The effect will be the same, if sugar of lead, ceruse, or minium, be boiled to a due consistence, either in oil of turpentine, oil-olive, or any distilled essential oil. Whence it is evident, that metals are dissolvable, or reducible to balsams with oils; in agreement with the doctrine of the chemists, but contrary to the opinion of the vulgar; tho the thing was known to the ancient Greeks and Egyptians, and is daily practised in the boiling of plaisters and unguents.

Virtues of the production.

3. This balsam is much commended against external inflammations, scirrhus tumors, and venereal ulcers, buboes, &c. Basil Valentine is extravagant in its praises; but I could never find that it had any extraordinary or specific virtues, more than the common balsam of sulphur.

PROCESS CLXI.

Exhibiting the conversion of LEAD into Glass, or the preparation of Vitrum Saturni, with sand.

The process.

1. **T**O one part of ceruse, minium, or litharge, add two or three parts of the powder of clean, white sand, or calcined flints, and grind them well together in a mortar; put the mixture into a strong crucible; detain it in

a fire of fusion for half an hour, and the matter, towards the top of the crucible, will, when cold, appear in the form of a transparent, brittle, or vitreous body, called the glass of lead; the metal, if any remain unreduced, subsiding to the bottom.

2. To make the flux the stronger, a due proportion of dry nitre may be added to the mixture, either before or after it is melted. Or the process may otherwise be performed, by taking four parts of minium, and one part of calcined flints or sand, and fluxing them with two parts of sea-salt, in a very violent fire. After which, the crucible being suffered to cool, upon breaking of it the upper part of the matter will be found vitrified; what is metalline remaining at the bottom. And this shews us the general method of reducing all metalline bodies to glass; which is done by first bringing them to a calx, and then fusing them in a close crucible with sand.

3. This glass of lead, otherwise called metalline amber, being fused in a test, will readily flux any other body that is put to it; upon which the whole art of refining or assaying entirely depends: for if any metalline glebe, or ore, tho' ever so much mixed with stones, sand, or other heterogeneous bodies, be but fluxed, or cupelled with this glass, it drinks in all the metal they contain, and throws to the surface whatever is of a different nature. And if the fire be violent, and long continued, the glass it self will run, like water, thro' the pores of the cupel; leaving nothing but pure and perfect gold or silver behind it. Whence lead is not improperly called by the chemists the bath, devourer, or purger of metals. Thus in order to purify silver, or separate it from its ore, we need only fuse or cupel it with about four times its weight of glass of lead, till, by blowing with bellows upon the face of the metal, all the impurities are driven off, and the surface of it is left pure and shining, and the glass of lead is run thro' the pores of the cupel. And if any vessel could be found capable of containing this glass in fusion, we should then have an admirable method for making silver.

CHEMICAL HISTORY of SILVER.

PROCESS CLXII.

Exhibiting the Solution and Crystallization of SILVER, in Aqua fortis.

1. **P**UT any quantity of perfectly pure silver, cupelled with lead or vitrum Saturni, into a clean glass; pour upon it about an equal or double weight of proof spirit of nitre, or Aqua fortis, and the liquor will presently conceive a degree

Processes upon Fossils.

degree of heat, emit a copious red fume, which is carefully to be avoided, and at length the body of the metal will be perfectly dissolved into a pale, homogeneous, transparent liquor, like water in appearance. But if the solution does not proceed to expectation, more spirit of nitre may be added, by degrees. (2.) When the solution is thoroughly effected, let one half of the liquor be evaporated over a gentle fire, in a chimney, to carry up the fumes; after which, if set in a cool place, it will shoot into gleses, thin plates, or crystals, of an exceeding bitter taste, which are called the vitriol, salt, magistery, or crystals of silver.

The cautions it requires.

2. Unless the silver be made perfectly pure and fine, that is, unless it has been fulminated or cupelled, as the chemists call it, with lead, and freed from all dross or allay, so as not to lose of its weight in the strongest fire, the solution will not be limpid; and if ever so little copper remain in the silver, it will turn the solution of a greenish colour. The spirit of nitre, likewise, should be proof; that is, if a grain or two of silver be added to a moderate portion thereof, it should perfectly dissolve it without growing turbid, or letting any white powder fall to the bottom. And if the dissolution proceeds too slowly, it may be quickened, by placing the containing vessel in a moderate heat. If any gold happens to be mixed with the silver, as there is scarce any without, this not going from it upon the test, it will fall to the bottom of the glass, in the form of a black powder or pellicle, and there lie undissolved; *Aqua fortis* not touching gold, which is only dissolvable by mercury and *Aqua regia*. And this black powder will sometimes adhere to the under surface of the crystallized silver.

Nature and uses of the productions.

3. This solution of silver is violently corrosive or caustic, so as presently to eat into any part of the body. On which account, 'tis very useful to surgeons, in opening impostumes, or the like; and admirably serves to take away warts or other excrescences, which it does with the utmost dispatch. It is likewise used to mucous fistula's, and putrid, gleeted ulcers, in order to deterge them, and keep down fungous flesh. A few drops of it being mixed with a pint of water, will communicate such a faculty thereto, that if the face, hands, or other parts of the body be washed with it, they instantly turn black; and this stain remain so obstinate, that it cannot, without the utmost difficulty, be entirely got out again in less than three or four days time; when, the part scaling, it comes away together with the skin. And as the solution readily mixes with water, we see that even the hardest and purest metals may be rendered fluid, potable, invisible, or undistinguishable. I would not, however, advise, that silver should be exhibited internally in this form; because of the corrosiveness of the acid wherewith it is united, which might cause it to excoriate the parts it should touch or pass over.

4. The vitriol, or crystals of silver obtained by this process, are found to increase their weight by near one third or fourth part, above that of the original metal; which must, therefore, attract, and lodge in its pores, some part of the spirit of nitre, by means whereof the silver

silver is made to assume the form of a salt, and become soluble in water. But its violently bitter taste, on account whereof 'tis called metalline gall, together with its caustic quality, renders it unfit for internal use, unless it be some way guarded, disguised, or corrected. And even when used externally, it cannot be held in the naked fingers without corroding the flesh.

P R O C E S S CLXIII.

Exhibiting the preparation of the Lunar caustic, or Lapis Infernalis, from the Vitriol of SILVER.

1. **P**UT a proper quantity of the vitriol, or crystals of well purified silver into a thin glass dish, which being set over an open fire, the vitriol will begin to afford red fumes, and grow gradually dry. As soon as all its moisture is nearly evaporated, increase the fire, and cause it to flow like wax, till no more fumes ascend: then pour it into moulds of baked clay, and furnished with a sufficient number of conical or cylindrical cavities, into which it will run with a hissing noise, and thereby be fashioned into convenient rolls, or sticks; which, when cold, may, by breaking the mould, be obtained, and reserved for chirurgical uses, under the name of Lapis infernalis, or the silver caustic*.

2. If this caustic be prepared after the manner here described, it will be capable of enduring the open air without relenting; whereas that made in the common way of the trading chemists, can scarce in a lose glass be kept, for any considerable time, from melting. The reason whereof is, that either they do not make use of silver well purified from its alloy, or else because in fusing their crystals, they have not patience to wait till the fumes entirely cease; that is, till a proper quantity of the acid of the nitre be exhaled. For if any copper, or too large a proportion of *Aqua fortis*, be mixed along with the stone, it will certainly run *per deliquium* in the air. The goodness of the preparation greatly depends upon nicely hitting the time when the fumes entirely cease to rise; for if the matter be after this continued much longer in fusion, its caustic virtue will be lost; and if removed from the fire before this juncture, it will, as we said, be apt to run in the air. The glass to be made use of in the operation is ordered thin, because such an one will better endure the necessary violence of an open fire, than one that is stronger or thicker: a piece of a broken urinal, or the like, will, therefore, be proper for the purpose.

3. *Lapis infernalis* then, we see, is no more than the strong and corrosive spirit of nitre intimately united with the body of silver, or no-

Medicinal uses of the production.

* The moulds ought first to be warmed, and oiled or greased, that the caustic may be separated from them the easier.

thing but the dried salt thereof; for if it be entirely freed from the remaining part of the *Aqua fortis*, it will become pure silver again. Thus composed, it makes an admirable caustic; for it eats like fire it self, when dissolved by any moisture of the body, and suddenly cleanses and deterges all foul or malignant ulcers, cauterizes the open vessels therein, disposes them to heal, and, with the lightest touch, takes down warts, fungous flesh, small cancers, and the like præternatural tumors or excrescences, provided they are not large. I have, without pain, in the space of three days, taken away a little cancer in the lip by its means: for being several times touched therewith, it turned black, and at length fell off from the surrounding flesh. When applied to any part of the body, it immediately eats into it, burns it, mortifies and renders it insensible; at the same time causing an eschar, and constringing and purging up the mouths of the vessels it corrodes. And being so excellent in these respects, it is the only caustic in use among the *French*.

P R O C E S S C L X I V .

Shewing the way of making purging Vitriol of SILVER, or the preparation of the Silver Pill.

The process.

1. **T**O the solution of pure silver, made after the manner of the hundred and sixty second process, and put into a glass vessel, add an equal quantity of a strong lixivium of purified nitre, made with about two or three parts rain-water; shake them together, and they will unite into a transparent liquor; which being evaporated to half its original quantity, and set to shoot in the cold, will run into a vitriol, or crystals, consisting of silver united with salt-petre. (2.) Put these crystals into a glass dish, and exhale away their moisture over a soft fire; keeping them in the mean time, perpetually stirring, and preventing their fusion. (3.) Remove them from the fire, and when they cease to fume, they will appear in the form of a black, saline body, a grain or two whereof being brought into powder, and with thrice that quantity of new bread reduced to a pill, and gilt with gold, to guard it from the palate, makes a pleasant and powerful hydrogogue, or purger of water in the dropsy.

*Virtues and uses
of the produc-
tion.*

2. This process shews us a general method of joining metals with salts, so as to make them appear altogether in a saline form. *Angelus Sala*, the author of the production, calls it by the name of *Luna hydrogoga*, as being peculiarly excellent in purging away the watery humors collected in the dropsy; for which purpose, it is likewise greatly commended by the illustrious *Boyle*. And indeed it proves, when prudently used, an admirable purgative in this case; and drains off the waters without causing any disturbance to the body. But great care must be taken not to give it in weak habits of body, in too large a dose, or where the viscera are unsound. For differing not considerably from the lunar caustic, it might thus violently stimulate, corrode, or inflame the stomach and intestines, bring on a dangerous hypercatharsis, or solicit a copious,

copious, continual, and insensible discharge from the lymphatics. If any thing of this kind should happen in the use hereof, it will be proper to attempt its cure by the free exhibition of the rob of juniper or elder.

PROCESS CLXV.

Exhibiting the Precipitation of SILVER, and its reduction to Luna cornea.

1. **T**O a solution of pure silver, made with spirit of nitre, and diluted ^{The process.} with about thrice its quantity of fair water, pour a strong lixivium of sea-salt; upon which, the liquor that was perfectly clear before, will immediately grow turbid, and let fall the body of the silver in a white powder, to the bottom of the containing glass. Commit this powder, together with the liquor that floats above it, to the filtre; and by frequent ablution, or repeated affusions of warm water upon the matter in the filtre, edulcorate or clear it of its loose salt; then gently dry the powder, and thus it will be reduced to a genuine calx of silver. Lastly, put this dry calx into a crucible, and fuse it at a moderate fire; and after it has run for some small time, pour out the matter, and when cold it will appear in the form of a horney, brittle substance, not much unlike amber, or glass of lead; and, for the resemblance it bears to horn, 'tis called by the name of Luna cornea.

2. There is another way of making Luna cornea, by mixing silver with ^{Varied.} mercury sublimate, and distilling the composition in a retort, after the manner of butter of antimony, the process for which we shall deliver hereafter; when, the mercury being driven over into the receiver, the salts of the sublimate will remain behind, fixed in the body of the silver, and therewith compose the same kind of horney, or glassy substance, as mentioned in the process.

3. This process affords us several very remarkable particulars. And ^{The doctrine it affords.} first we may observe from it, that silver is undissolvable in Aqua regia; being, as we see, precipitated out of Aqua fortis, made into a small Aqua regia, by the addition of the lixivium of sea-salt. Secondly, tho the Luna cornea be long exposed to ever so violent a fire, it will not, without some addition, be thereby reduced to metal again; tho, beyond all dispute, it is actually the body of silver fixed but by salts. And accordingly, if lead, or fixed alkali, be added in a proper portion thereto, so as to attract or imbibe the acid salt, which thus obstinately adheres to the metal, and its face be strongly blown upon with bellows, whilst it is in strong fusion, the silver will be recovered pure; and if, after this, it be again dissolved in Aqua fortis, it affords a considerable proportion of gold. Thirdly, it is farther observable, that this strange substance, reduced to powder, tho it readily melts at the fire, will neither dissolve in Aqua fortis, Aqua regia, nor oil of vitriol; so that it entirely acquires a new nature. On these accounts, many of

the antient chemists called it *Luna fixa*; and imagined the body of the silver was here so changed as to be readily convertible into gold: and indeed, the experiment does not seem to want much to bring it to that perfection. Lastly, we may here see the great effects which salts have upon metals; how they may contribute to their fixation; and, by intimately and strongly uniting therewith, conceal their own nature, and endure the utmost torture of the fire without flying off; tho of themselves they are little other than volatile.

PROCESS CLXVI.

Exhibiting the Reduction of SILVER to metal again, from its inflammable Vitriol or Nitre.

The process.

1. **P**UT *Lapis infernalis*, or the crystals or vitriol of silver, obtained by dissolving the metal in spirit of nitre, upon a hollow, glowing coal, and it will immediately flash, deflagrate, and go off like true salt-petre; leaving nothing behind but the pure silver, thus recovered from its crystals.

The doctrine it affords.

2. We formerly saw that the spirit of nitre, joined with fixed alkali, gives inflammable nitre again; and here we see, that the body of a metal may likewise perform the same office. It also appears from this process, that nitre, tho made liquid, or reduced into the form of a spirit, still retains its saline and inflammable nature; and that *Lapis infernalis*, or vitriol of silver, is nothing more than this volatile spirit of nitre, adhering intimately to the body of the metal; and which, when driven away by the fire, leaves the silver behind, as it would any other metal dissolved thereby, in a pure, simple, and unactive state: which gives us the reason why, if *Lapis infernalis* be too long detained in fusion at the fire, it will thereby lose of its force, or caustic virtue, by losing of its salt. And this may serve to shew us, that the actions of all metals are not owing to themselves; they being perpetually unactive; but to the saline bodies with which they happen to be mixed; and according to the nature whereof their action is determined. But in this case, the power and virtues of the salts are necessarily increased, as being now applied, and driven by the ponderous, metalline part, united with them, against the bodies they are designed to act upon. And this will help us to conceive something of the surprizing nature of metals, when formed into new bodies with salts.

CHEMICAL HISTORY of TIN.

PROCESS CLXVIII.

Exhibiting the Calcination, Solution, and Crystallization of TIN.

1. **P**UT any quantity of pure * tin into an iron or unglazed earthen pan, ^{The process.} and melt it in a strong fire; keeping the matter continually stirring, till it be reduced to a dry powder, or calx. (2.) Then put of this calx of tin into a glass vessel, and pour thereon about ten times its quantity of distilled vinegar, and let them digest together in a proper degree of heat; the glass being frequently shook, for two or three days, or till the menstruum has acquired a sweet taste; or till the solution is effected. (3.) Lastly, filtre the liquor, evaporate it to a film, or pellicle, and set it in a cool place to shoot; by which means it will form into crystals.

2. The body of tin is not so readily convertible to salt, or vitriol, as ^{Directions relating to it.} silver; on account of the gross sulphur adhering thereto, which can never be dissolved by acids, but interposing between the metallic parts, prevents its concretion. But if the calx be thorowly purify'd, reverberated, or long continued in a violent fire, it will in good measure be freed of its sulphur, and more disposed to shoot into crystals. †

CHEMICAL HISTORY of COPPER.

PROCESS CLXVII.

Exhibiting the Solution and Crystallization of COPPER, by means of distill'd Vinegar.

1. **U**PON the filings of pure copper, put into a glass vessel, pour a proportionable quantity of distill'd vinegar, and boil together for four and twenty hours; by this means there will be obtain'd an exceeding beautiful green ^{The process.}

* The common method of purifying tin for chemical operations, is to melt it in a clean iron pan, and just as it begins to run, adding thereto a suitable proportion of wax, honey, or hogs lard; keeping the matter frequently stirring with an iron rod, and after some time throwing it into hot water. If this operation be several times repeated, the metal will, in some degree, be purged of its sulphur, and render'd more bright and hard.

† There are other processes commonly performed upon tin, tho not deserving to be mentioned here, as being no part of the present design; which is only to give such a set of general, standard operations, as may instruct the reader to manage all the others that have hitherto been invented.

since

tincture; which being poured off from what remains undissolved at the bottom of the glass, and fresh vinegar put on, and boiled as before, the whole body of the metal will, by repeated operations, be dissolved into the like green tincture. (2.) If this tincture be evaporated to a pellicle, and set in a quiet cool place, it will shoot into lovely green crystals; which are used as a pigment, and commonly go by the name of verdigrease.

Varied.

2. This vitriol of copper, or verdigrease, may likewise be obtain'd by exposing clean plates of the metal in any place where they are affected by the vapors of vinegar, or fermenting liquors; which gradually corrode and turn the surface thereof into a kind of rust, or *arugo*, that by the microscope appears a heap of green crystals, like those of the present process. Then the loose matter being scraped off the plates with a knife, and they again exposed to the corroding vapour, they will thus by degrees, be totally converted into the common verdigrease of the shops.

Nature of the production.

3. This green vitriol of copper would be an admirable pigment, if its colour could but be render'd as durable as it is beautiful. Whoever could do this, might think himself possessed of a very beneficial secret. The reason why it loses of its beauty in the air, is the volatility of the acid wherewith the metal is joined; which being exhalable by the air, it leaves the metalline part of a grey, dusky colour.

Its medicinal virtues and uses.

4. This tincture and vitriol of copper are possessed of the same medicinal virtues; a very few drops of the former, or a single grain or less of the other, make an excellent emetic, where the occasion for one is very pressing and sudden; as particularly in case of poison receiv'd into the stomach. For as soon as taken, this medicine operates powerfully by vomit; but leaves a very disagreeable or nauseous styptic taste upon the tongue, for many hours after. It likewise destroys all kind of worms in the body, serves to dry up old gleeting ulcers, takes down fungous flesh, &c. and indeed it acts after the manner of *lapis infernalis*, but much more gently.

P R O C E S S C L X I.

Exhibiting the Solution and Crystallization of COPPER, with the alkaline spirit of Sal-Ammoniac.

The process.

1. **U**PON clean filings of well purified copper, put into a tall glass, pour twenty times their quantity of the alkaline spirit of sal-ammoniac, prepared with quick-lime, and proceed as in the foregoing process; by which means the copper will be dissolved into a fine blue liquor, which being exhaled till a film appears on the surface, will in the cold form it self into crystals, or vitriol of the same colour.

Nature of the production.

2. This vitriol, likewise, is an excellent pigment, but presently loses all its beauty; the volatile alkali wherewith the copper was dissolved, easily flying off from it in the air: otherwise it would be more precious

precious, as it is of a much more elegant colour, than ultramarine; which being sold so dear, it would be a valuable thing cou'd we make the colour of this vitriol durable.

3. The tincture obtain'd by this process is not so vomitive as that of the preceding; and being given in the quantity of a few drops, operates powerfully by sweat and urine; whence it becomes curative of many diseases, and particularly the dropsy. And in this case I have found it effectual to a surprizing degree, even in old-age, when the collected water by long stagnating was almost putrefied in the body: by giving thirty drops of the solution, three or four times a day, with a little hydromel or syrup of juniper, there has follow'd such a copious discharge of urine, that in a short time all the stagnant waters have been entirely brought off that way. But when the dropsy is attended with a schirrhous liver, unsound viscera, or the like, I could never observe any good effect from this, otherwise, excellent medicine. It is likewise serviceable in killing worms, bringing away phlegm, and curing faintness, the rickets, and epilepsy, if, as frequently happens, in children, it proceeds from worms in the body, or viscid phlegm in the stomach. In general, it is of an attenuating, aperitive, stimulating, warming, drying virtue; and may in ordinary cases be given from twelve to four and twenty drops, three or four times a day, along with any vehicle that is not acid, which might render it emetic. Thus managed, and given in smaller doses to children, 'tis likewise wonderfully effectual in the cure of those distempers to which they are peculiarly subject.

4. We learn from this process, and the preceding, that copper is dissolvable in alkaline as well as in acid spirits. We may add, that it will likewise dissolve in neutral spirits, in *aqua regia*, *aqua fortis*, in *sal volatile oleosum*; and, in short, in all manner of saline menstrua. On which account it is generally called a public prostitute, by the chemists, and denoted by the name of *Venus*. With *sal volatile oleosum*, it makes a tincture of nearly the same virtues as that of the present process, but much more beautiful; and it is this tincture which I frequently use in my practice, and prescribe from eight to thirty drops, as a diuretic, or sudorific, in case of the dropsy, or other distempers; and universally, with acids, or those the chemists call masculine salts, it makes a green, but with alkalies, or the female salts, a blue solution; the latter kind being always less caustic and emetic than the other.

Medicinal virtues of the production.

The doctrine of the process.

C H E-

CHEMICAL HISTORY of MERCURY, or QUICK-SILVER.

PROCESS CLXX.

Exhibiting the Solution and Crystallization of QUICK-SILVER, in Aqua fortis.

The process.

1. **T**O a proper quantity of pure quick-silver, * strained thro leather, and well ground in a mortar with sea-salt and vinegar, till it has deposited all its blackness, pour a double or a triple proportion of aqua fortis, the containing glass being first heated to prevent its cracking, and the mercury will immediately begin to dissolve, with a strong ebullition, and copious red fumes, which are to be avoided as noxious; and by degrees the whole body of it will be taken up, and with the menstruum appear as one homogeneous and transparent liquor. If the dissolution proceeds not to expectation, or it be incomplete, more aqua fortis should be poured on, and the operation thereof promoted by moderate heat. (2.) If this solution be exhale, over a soft fire, to one half or less, and then set in a cool place, it will shoot into white glebes, or crystals, called the salt vitriol, or magistery of mercury; being in reality the body thereof, so united with the acid that it is violently caustic, and can scarce be kept from running per deliquium in the air.

Its use, with the nature of the subject.

2. This process may serve to shew that mercury is of a metalline nature; being, like other metals, strongly attractive of the acid of nitre, and totally dissolvable therein, so as to lodge invisible, and thence become miscible with water, like all true metalline solutions; and by this means the mercurial part of all, even the most ponderous metalline bodies, may be suspended in water; viz. by being first united with an acid salt, which is always strongly attractive of water. The properties, and so much as regards the natural history

* The mercury found near gold-mines is supposed the best, richest, and fittest for chemical uses; as being impregnated with a golden sulphur. In the earth it is often mixed with arsenical, and other heterogeneous matters, which tho imperceptible to the senses, may render it noxious to the body, without due purification. The clean, wholesom mercury, 'tis said, may be distinguished from the foul, or adulterate kind, by the fine white lustre, and polite or glossy surface of the former; and by evaporating it over a naked fire in a silver vessel;

for if it leaves no considerable tarnish behind, 'tis commonly thought to be pure. But it appears unsafe to depend upon any mercury for medicinal uses that is not revived from cinnabar, or fixed alkalies, or particularly from a double weight of the mixture of equal parts of quicklime, and salt of tartar: the grinding and washing it with salt and vinegar, being by some thought only to dissolve the body of the mercury, it self black, and not to free it from arsenical or other noxious particles.

of this metallic fluid, we have formerly mentioned in the *Theory*, or *Apparatus*; to which we therefore refer for those particulars. We shall only add here, that its chemical and medicinal virtues seem owing to its great specific gravity, and the particular smallness and configuration of its parts. On this account it is more penetrative, and dissolves the texture of the blood and juices, or opens obstructions in the body more powerfully than any other medicine. And for the same reason it is, that it so suddenly brings a degree of putrefaction upon the humours, as we find in a salivation; for by thus breaking the texture of the fluids, and sometimes of the solids likewise, it so attenuates and resolves them as to make them fetid. For whatsoever resolves the animal fluids, will necessarily give them a disagreeable odour; and therefore the ill-scent observable in a salivation, is neither chargeable upon the infection of the disease, nor upon the mercury, as if this had a power to set the virus on float, and discharge it with the fetid saliva out of the body. And these properties are what makes it so readily enter the pores of all metals, adhere to and amalgamate with them, unless they abound much with sulphur or earth; whence iron will not be at all affected by it.

3. The solution of mercury in *Aqua fortis*, is a violent corrosive, and will, like a solution of gold, turn any part of the body it touches of a purple colour, which cannot easily be removed again. It is sometimes successfully used, as a caustic, to callous or tumefied venereal ulcers; tho' it is so strong, and causes such violent pain, that it ought never to be apply'd to ulcers in the *penis*, where the skin is exceeding delicate and tender. It will instantly take away warts, small cancers, and other excrescences, if cautiously and properly applied. A few drops of it diluted with a large proportion of water, makes an admirable, safe, and mild cosmetic for red and pimply faces, which are to be wash'd with this lotion twice or thrice a day; and what is thus used, suffer'd to dry upon the skin. It is also an excellent wash, thus managed, in case of the itch, and all cutaneous foulness or ulcers. The *Aqua divina* of *Fernelius* was nothing more than a solution of mercury, either in spirit of salt, or spirit of nitre.

4. The vitriol or crystals of mercury are, in like manner, the most violent corrosive we know; and will instantly eat thro' the flesh, to the very bone. The tenth part of a grain thereof, being given internally, would cause strange disorders in the intestines, act both as a strong emetic and cathartic, and raise a salivation in a few hours time. But no prudent physician will venture to administer it in this manner, as being violently poisonous. This vitriol easily flows at the fire, has a very disagreeable nauseous taste that long remains upon the palate, and when dissolved and laid upon copper, instantly gives it the whiteness of silver. These several virtues and properties of it appear in great measure to depend upon the acid, wherewith the heavy body of the mercury is concentrated, and intimately united, or, as it were, stuck full of sharp saline
 O o *Spicula,*

Medicinal virtues of the solution.

Virtues, properties, and uses of the vitriol.

Processes upon Fossils.

spicula, which thus adhering to the globules of the quick-silver, it is thereby made to act powerfully upon every thing wherewith it comes in contact.

PROCESS CLXXI.

Exhibiting the precipitation of MERCURY out of Aqua fortis ; or the preparation of White Præcipitate.

The process.

1. **T**O the solution of the foregoing process, made with Aqua fortis, add thrice its quantity of fair water, which will cause no cloudiness in the liquor ; afterwards pour thereto about twice as much strong lixivium of common salt as there was of the solution of mercury, and the mixture will immediately grow milky, and precipitate a white powder to the bottom of the containing vessel. Then pour the whole mixture, together with the powder already precipitated, into a filtre, and wash the remaining cake, by the frequent affusion of warm water, till what runs from it becomes inspid, and there will a pure, white powder be left in the filtre ; which being dried before the fire, is called by the name of the white præcipitate of mercury.

The doctrine it affords.

2. It appears from this experiment, that mercury is readily dissolvable in Aqua fortis, but difficultly in Aqua regia ; which, however, will take up some part thereof. For the water used to wash the præcipitate, carries some mercurial particles thro' the filtre : on account whereof, it becomes a good cosmetic ; and for cutaneous disorders is preferable to the Aqua divina Fernelii. And therefore, if we were to conclude from this experiment, mercury should seem to approach nearer the nature of silver than of gold.

Medicinal virtues and uses of the preparation.

3. This white præcipitate is more powerful in its operation than crude mercury, but more languid than the crystals or vitriol thereof, obtained by means of Aqua fortis ; as being, by the ablution, in great measure freed from its corrosive salt, and made less caustic ; so that it may be safely given internally from three grains to ten *, along with some proper purgative, to determine its operation to the intestines. And thus it becomes an excellent cathartic in all venereal complaints, and where phlegm, or worms are lodged in the body ; as also in the itch, or other cutaneous distempers. If taken in small doses, as the quantity of two or three grains, and repeated at proper distances, for some days successively it raises a salivation very well ; and upon this account, is held under a disguise, as an excellent panacea of mercury, by many who practise physic : but if given along with something warm, to determine its virtue to the surface of the body, it then becomes a sudorific. Mixed in a moderate proportion with pomatum, or ointment of roses, it makes an admirable unguent for the itch, leprosy, and ulcers of the skin : and

* This medicine is very seldom, if at all, prescribed internally by the English physicians, tho, if cautiously used, it is safe enough, and has wonderful virtues in the Lues venerea, and cutaneous diseases.

if mixed in a still less quantity therewith, as in that of a twentieth or thirtieth part, an excellent cosmetic †. And if in making the solution of mercury for this medicine, a little copper be added, the precipitate will be of a green colour, and have much the same virtues; being emetic as well as purgative, in the quantity of a few grains, and called the green præcipitate of mercury, and by some the green lizard.

PROCESS CLXXII.

Exhibiting the red Præcipitate, or Calx of MERCURY.

1. **L**ET the crystals of mercury, obtained in the manner of the hundred The process. and seventieth process, be exposed to a soft fire, in a proper glass vessel, and gently evaporated, with care to avoid the noxious fumes; and as it increases in degree of dryness, so it will change colour from white to yellow; and at length if kept constantly stirring, and urged with a strong fire, become of a perfect shining red; in which state, being removed from the fire, it is the red præcipitate of mercury, and appears not much unlike to minium.

2. If the action of the fire should be too long continued, it would Its nature and effects. drive away all the acid, and leave nothing behind but pure mercury, recovered in its native form; and, therefore, is not perfectly fixed by the spirit of nitre. This red powder, however, is capable of being considerably fixed by repeated dissolutions and exhalations; tho it will still be recoverable again, and rendered volatile, by violence of fire. This increase of the fixedness in the calx of mercury, has caused some chemists to call it horizontal gold, or gold in the horizon, and to look upon it as a substance nearly allied to that metal. Sylvius writes, that mercury may be made to afford gold by means of spirit of nitre; and Helmont had a method of rendring it still more fixed, by mixing it with the white of an egg, and afterwards distilling it in a retort: but we do not find that it will thus be made to endure a blast-fire. By being mixed with alcohol, and distilled in a retort, the remaining matter becomes more mild and gentle: and when thus treated, it seems to be the *Arcanum Corallinum*, or *Saltabrum* of Paracelsus. By repeated deflagration with pure spirit of wine, it may, as well as by a stronger heat, be reduced to mercury again; and, like the white præcipitate, it loses of its caustic virtue by frequent ablution. Whence we see it confirmed, that mercury may be used in greater quantities, the less proportion of acid it is mixed with.

† This precipitate is found an extraordinary medicine for external uses, and may be managed to all the desirable advantages of cleanliness, inoffensiveness, and efficacy, either by way of lotion or unguent: and is the grand secret of some, when dissolved in water, for curing the itch, or leprosy, and destroying all kinds of vermin, without daubing the linen, or giving any offensive scent. But where there is any rawness, it ought either to be well edulcorated, or mixed in a very small proportion with other ingredients, otherwise it will cause a considerable pain or smarting.

Medicinal virtues and uses of the production.

3. This red calx, improperly called præcipitate, is stronger and more corrosive than the white præcipitate of mercury, and purges violently both upwards and downwards, in half the dose of the other: being generally used for much the same purposes with that. But as it is apt, by its corrosiveness, to corrode and exulcerate the stomach and intestines, I cannot recommend the internal use thereof; tho it appears to have been the medicine so successfully employed by the woman at *Paris* in desperate venereal cases, given over by the physicians of the place. She ordered it in the quantity of eight or ten grains, to be taken every morning, for three or four days running; by which means it first vomited, then purged violently, and lastly salivated; and sometimes too it killed the patient, when he happened to be weak. The like effect may likewise be produced by turbith mineral. 'Tis highly valued by chirurgeons as an internal for taking down fungous flesh, cleansing foul ulcers, drying up their moisture, and disposing them to heal.

P R O C E S S CLXXIII.

Exhibiting the Solution of MERCURY with oil of vitriol.

The process.

1. **T**O a proper quantity of well purified quick-silver, put into an urinal, pour four times its weight of good oil of vitriol, and set the vessel in an open fire; upon which a copious, white, and very destructive fume will ascend, and the whole body of the mercury be converted into a white calx or powder; let the matter continue upon the fire, taking care to avoid the noxious vapour, till it almost ceases to smoke, or be turned to a grey powder; which is the mercury it self dissolved by the oil of vitriol, and rendered most violently corrosive, fiery, and poisonous.

Its nature; with that of the production.

2. The oil of vitriol, in this case, does not, like spirit of nitre, reduce the mercury to a salt; and will scarce act at all upon it, without the assistance of a considerable heat, how long soever it stands thereon; which may let us see that some menstruums will not act till put into motion by some general cause; as for instance, by the air, fire, water, trituration, &c. and indeed the solution will never be perfect unless the matter be made to boil. A thin glass, or urinal, is more proper for this operation than a retort, which will not so well endure the fire, and might, upon breaking, prove of dangerous consequence; for the fumes are suddenly suffocating, as the preparation it self is highly and immediately poisonous if received into the body; being a most violent acid lodged or concentrated in the body of the metalline mercury: whence it is easy to account for its corrosive power. It is the most corrosive and fiery of all the preparations of quick-silver, except the following; and has scarce any medicinal use, unless it be to serve the purposes of chirurgery, and in the preparation of *turpethum minerale*. Less than

than a grain, being received into the stomach, might cause a vomiting of blood, a dysentery, bloody urine, a salivation, and death.

PROCESS CLXXIV.

Exhibiting the fiery Oil of MERCURY when dissolved with oil of vitriol.

1. **T**O the grey powder of the preceding process, add an equal weight of The process. good oil of vitriol, and again expose it to the fire, and treat it as there mentioned; by which means the mercury will again be totally dissolved into a thick, ponderous liquor, and exhaled to a powder; which, by several times repeating the operation, will at length be brought into so fixed an oil, that the heat of ebullition, or even the most violent fire, can hardly dry it; and so strong a caustic, that it may justly be called the fiery oil of mercury.

2. The fumes arising in this process are to be carefully avoided, as highly poisonous and destructive to the lungs. The oil it self is the strongest corrosive yet known in the world, or that, perhaps, can possibly be made; whence 'tis aptly enough called *ignis Gehenna* by *Paracelsus*; scarce any thing being able to withstand its force. This, however, is not the metallic oil of the adept; because it is joined with a menstruum, whereas that ought to be perfectly pure and unmixed; but the experiment will serve to shew us how acids may be concentrated with the mercurial part of metalline bodies, into the most violent, corrosive oils in nature; which being once dried by the long continued action of a vehement fire, will remain fixed therein, or even almost endure a blast-heat: and this, therefore, shews us an approximating method of fixing mercury. And perhaps all fixation of metals may be owing to nothing more than the strong union of their parts with a ponderous acid salt, which will not easily suffer their texture to be broken*.

3. The medicinal uses of this fiery oil are not very considerable, unless in chirurgery, where it may serve for extirpating cancers, or the like: but no one would ever dream of giving it internally. I make no question but an exceeding small quantity of it, being received into the stomach, would instantly dissolve its substance, or forcibly tear it to pieces. uses of the production.

* Whether it be salt or sulphur that fixes the mercury of metals, has not yet been made evident by undeniable experiment; but the diligent *M. Homberg* affords us many curious observations which tend to shew it is sulphur; or, in other words, the matter of light. Yet all metals seem to contain a latent salt; by means whereof their terrestrial part is thought, by strong fusion, to be convertible into glass.

PROCESS CLXXV.

Exhibiting the preparation of Turpethum minerale, from the solution of MERCURY in oil of vitriol.

The process.

1. **U**PON the dry powder gained by dissolving mercury in oil of vitriol, after the manner of the last process but one, pour a proper quantity of warm rain-water; and the powder will immediately turn of a yellow colour. Continue to wash this powder by repeated affusions of water, till the liquor comes away as insipid and colourless as it was poured on, leaving a beautiful yellow calx at the bottom of the vessel; which being gently dried at the fire, is called by the name of turbith mineral.

Nature of the production.

2. This powder is called *mineral turbith*, from the resemblance it bears to the vegetable turbith of the *Arabians*, in strongly purging the most internal recesses of the body: for, tho it be insipid upon the tongue, yet it is possessed of very considerable virtues. Being boiled with water, it loses more of its salts, and thereby grows milder and more safe: so it does by being deslagrated twice or thrice, or distilled with spirit of wine.

Its medicinal virtues.

3. A very few grains of this turbith will prove emetic and purgative: it is also accounted a most excellent medicine in the cure of the venereal disease. But as it operates with considerable violence, it ought not to be given unless the viscera are known to be sound. This seems also to be the mercurial powder mentioned by *Mr. Boyle*, as received in a very small quantity at the nose, by way of snuff, whereby a certain captain was perfectly cured of a total blindness, caused by cataracts; the medicine operating by sternutation, vomit, stool, sweat, urine, and salivation, for a very long time together. But this universal manner of operation is not peculiar to turbith mineral; all the præcipitates of mercury will do the same, when snuffed up the nostrils; but their operation is so violent, and the disorders they cause so intolerable, and succeed so fast, that it is shocking to think of prescribing them in this manner. This likewise appears to have been the grand secret of *Paracelsus*; which, in his scarce *German* book of hospital medicines, he praises so extravagantly for venereal and all chronical diseases. *Sydenham* also commends it in venereal cases, given in the quantity of six or eight grains, in strong habits of body, so as to prove emetic: but when imprudently used, it is apt to give the dysentery.*

P R O.

* Here might properly follow the preparation of corrosive sublimate of mercury, and from thence of *Mercurius dulcis*, in order to complete the series of processes made upon mercury with salts, before we are conducted to

those performed upon it with sulphur. But the process for making this mercury sublimate, being omitted by our author as no part of his design, it may be supplied in the following manner.

Preparation

PROCESS CLXXVI.

Exhibiting the Reduction of MERCURY into Æthiops mineral, with Sulphur.

1. **T**AKE equal weights of purified quick-silver and flowers of sulphur, The process. and grind them well together in a stone mortar, till the globules of mercury become invisible, and the whole mixture is turned to a black powder; that is, till the body of the mercury is intimately united with the sulphur; which then makes what is called Æthiops mineral, and improves in blackness the longer it is ground.
2. It appears by this process, that sulphur may, in the mines, readily its physical use. unite with fluid mercury, and form a fixed, black mass, of a nature entirely different from both; which, however, is accounted the best ore of quick-silver. The way to recover the mercury out of this powder, or black mineral glebe, is to grind it with an equal quantity of iron filings, and then distil it with a strong fire, in an iron retort, which will send over the mercury revived and purified.
3. This black powder, tho' taken in very large quantities, will not Medicinal virtues of the production. salivate like other preparations of mercury, and indeed cannot be dissolved by any of the animal fluids; whence it can scarce possibly enter the lacteals, but runs untouched thro' the intestines: by which means, however, it may gently stimulate their coats, solicit a discharge of their contents, destroy the worms it meets with there, and serve to cure such disorders of children as proceed from causes seated in the *prima viæ*; for which last purpose it is found very effectual. In other respects it seems to be unactive in the body; the mercury lying dormant in the sulphur, and requiring to be mixed with purgative or other proper ingredients to bring it into action; by which means it may be rendered serviceable in cutaneous, phlegmatic, or venereal diseases; the cure where-

Preparation of the corrosive Sublimate of MERCURY.

GRIND together equal quantities of clean mercury, revived from cinnabar, calcined vitriol, nitre, and dephlegmated salt, till the globules of the mercury become invisible; then put the mixture into a glass retort, and sublime by degrees of fire in a sand-furnace. When all is cold, let the glass be broken with care to avoid the poisonous fumes, or light dust that may arise, and take away the sublimate adhering, in the form of a white glebe, to the sides thereof; which may again be sublimed with an equal weight of oil of vitriol, and dephlegmated salt, to render it more corrosive.

This sublimate is a very violent poison, and proves mortal in the quantity of a few grains: it is, therefore, never used internally. But when dissolved in lime-water, it makes a good lotion for foul, eating ulcers, the itch, and other cutaneous diseases. It likewise serves to take down fungous flesh, and answers other purposes in chirurgery. Its principal use is the share it has in the preparation of that excellent medicine, *Mercurius dulcis*; which is made by grinding fresh mercury with it, and repeating the sublimation till the points of the salts are broken fine, or till the sublimate becomes sufficiently mild, and fit for internal use.

of it would never otherwise effect; contrary to the opinion of those who imagine the virtues of mercury to be exalted and raised when brought into such a state of inactivity, as renders it incapable of raising a salivation, by being made too gross or insoluble to enter the lacteal vessels, and mix with the blood.

P R O C E S S CLXXVII.

Exhibiting the preparation of artificial Cinnabar of MERCURY, with sulphur.

The process.

1. **T**AKE of *Æthiops mineral*, made after the manner of the foregoing process, with one part sulphur and three of mercury, and put it into an earthen, or *Hessian cucurbit*; carefully lute on a glass head, or receiver thereto, and sublime the mixture in a strong heat of sand, and the mercury will ascend along with the sulphur, and adhere to the sides of the glass in form of a fine red glebe, or artificial cinnabar, not to be distinguished in any respect, when reduced to powder, from the native cinnabar of the mines.

Varied; with the medicinal uses of the production.

2. The process may otherwise be performed by first fusing the sulphur, and mixing the mercury with it by degrees, which will then fulminate therewith: after this, the vessel being close covered and set to cool, the ingredients will be found run into a black mass, which, being ground to powder and sublimed, affords a beautiful cinnabar. In this preparation the mercury adheres more loosely than in the mineral *æthiops*, as will appear by the microscope; and therefore may sometimes raise a salivation. But if it be well and perfectly made, there is no danger thereof; for in that case it does not seem capable of entering the lacteals, tho it proves something more active in the first passages than *æthiops mineral*; and answers much the same intentions, being frequently used for worms, and by some for fits in children. In order to revive or recover the mercury again from this cinnabar, it need only be distilled from fixed alkali; which keeps the sulphur behind, and lets the quick-silver go over pure.

P R O C E S S CLXXVIII.

Exhibiting the Amalgamation of MERCURY with Lead.

The process.

1. **M**ELT a proper quantity of pure lead in an iron crucible; remove the vessel from the fire, and when the metal is a little cooled, pour to it an equal weight of clean mercury, which will immediately enter the lead with a hissing noise. Then stir the mixture well together with an iron rod, and, when cold, it will appear in the form of a softish, brittle mass, called the amalgam of mercury with lead.

2. 'Tis

2. This shews us the general method of amalgamating metals with mercury; all which, except iron and copper, will readily unite therewith: but gold with the greatest facility, silver with the next, then lead, tin, and copper; but it will scarce unite at all with iron. Whence we see that the affinity is greatest between mercury and the least sulphureous metals; and in particular that it may readily be adulterated with lead. Metalline bodies being thus made soft, or reduced to an amalgam, are fit for various uses, both in chemistry and other arts: thus, in particular, the art of gilding entirely depends upon it. If gold be amalgamated with quick-silver, and the mixture conveniently laid upon any other metal, as copper for instance, and this afterwards be placed upon the fire, the mercury will thereby be evaporated, and the gold alone left upon the surface of the brass; that is, the brass will thereby be gilt with gold.

3. If this amalgam of mercury and lead, which appears of a bright, silver colour, be well washed, and ground with fair, warm water, in a glass mortar, a copious black powder, or earth, will mix it self with the liquor; and if fresh water be several times poured on, and the ablution repeated, there will at length be obtained, as it were, a kind of silver, or universally a much purer substance than that employed in the amalgam; tho it will not become perfectly pure, how much soever it be washed, the water still growing black in the operation. 'Tis one of the greatest secrets in chemistry, to bring this liquor off as clear and unsullied as it was poured upon the amalgam; and might afford a method for making the nobler metals, or procuring them from the baser. Indeed this philosophical method of purifying metals, is it self no inconsiderable secret; especially as it may be applied to the purging of all metalline bodies, and even gold; which likewise may be made to deposit a black powder in the operation: whence mercury has been called the bath, or cleanser of metals. The powder gained by evaporating the several washings of the amalgam, has frequently been called the earth of the metal that affords it, but improperly: it seems rather to be the sulphur adhering to the metals, mixed with a part of their own mercury, or the quick-silver employed in the amalgamation.

4. The result of our several processes upon metals, is in short this. We are taught by them that metals can scarce at all be brought to act upon the body, but by means of salts, and particularly such as are acid and violently sharp, which dissolve and convert them into vitriol; that their power is always the greatest, as they contain the larger quantity of this acid, which being driven away from them, ground finer, or having its points broken, leaves them less active proportionably: and lastly, that this may be effected by long digestion, and ablution with water, precipitation, deflagration with spirit of wine, and thorough calcination. And thus at length we have finished the chemical history of metals; and are thereby prepared to enter upon the treatment of semi-metals, the subjects of our last link of processes; which we

shall deliver in the same geometrical order as hath hitherto been observed *.

CHEMICAL HISTORY of SEMI-METALS.

*Introduction to
the history of
Semi-metals.*

SEMI-METALS are divisible into two kinds; those which consist of a metal joined with a salt, as native vitriol; and those composed of metal and sulphur, as antimony: by the treatment, therefore, of these two, we shall endeavour to shew the method of treating all the bodies of this class, so as to give the chemical history thereof.

* This chemical history of metals will scarce be thought complete by the generality of our readers, however agreeable it was to the author's design, without taking the least notice of gold, the noblest among them. We will here, therefore, just mention the more remarkable experiments usually performed upon it. There are four different ways of purifying, or separating it from other metalline bodies, where-with it may happen to be mixed; viz. by the cupel, the depart, cementation, and melting it with antimony. When by any of these means it has been made thoroughly fine, and fit for chemical use, it may be reduced to powder, for several purposes, or rendered potable and volatile various ways, as particularly by amalgamation, mixing with other bodies, distillation with certain menstruums, &c. and may, if a person has the skill, be chemically treated with as much ease as silver; and be converted into a variety of medicines, to greater advantage, perhaps, than physicians are generally aware of. The proper

solvents for it are vulgarly esteemed spirit of sea-salt, and *Aqua regia*, by means whereof the *aurum fulminans* is made; this being no more than the calx, or powder of gold, precipitated with oil of tartar, or spirit of sal-ammoniac, out of a solution of that metal made in *Aqua regia*; and carefully dried before a gentle fire, to prevent its running together, and going off with a loud report, as it is very apt to do with a considerable heat; the acid spirit of the menstruum being thereby rarified, and breaking forcibly thro' the tenacious metalline particles, wherein, by the operation, it was lodged and imprisoned: which is the common way of accounting for this strange phenomenon. But the great price of the subject having proved a general hindrance to making the finer experiments thereon, whoever desires to see what uncommon things are performable with it, when treated by a judicious chemist, may consult the excellent Mr. Boyle upon that head, in different parts of his philosophical writings.

CHE-

CHEMICAL HISTORY of VITRIOL.

PROCESS CLXXIX.

Exhibiting the analysis of VITRIOL; or its calcination, and reduction to Spirit, Oil, and Colcothar.

1. **P**UT any quantity of good Hungarian vitriol into a proper, unglazed, ^{The process.} earthen pot, and set it in the middle of a strong fire, till the matter melts, ceases to fume, or becomes dry and white; and this is called calcining of vitriol to whiteness. (2.) Grossly bruise this calcined vitriol in a mortar, and with it fill two thirds of an earthen retort, that is able to endure the strongest fire, and apply, with a proper lute, a capacious receiver thereto. (3.) Set the retort in a reverberatory-furnace, gradually raise the fire, and at first there will come over, in strong fumes, a spirit of vitriol, for four or five hours; then increase the heat to the greatest degree the furnace will bear, and continue it for twelve hours at the least; by which the more ponderous acid, or oil, will be brought over into the receiver; leaving a whitish mass, called colcothar, at the bottom of the retort*.

2. Vitriol cannot, with prudence and safety, be analysed but in a ^{Cautions and directions relating to it.} spacious place, and with the utmost attention, to prevent the mischievous effects that might arise therefrom. In order to procure the acid of vitriol to advantage, the mineral need only be calcined as the process directs, and reduced to gross powder; after which, being by it self exposed to a violent fire, it yields first its spirit, and then its gross, ponderous oil. There is no occasion for the addition of any bole, or the like material, to separate the parts of the vitriol in distillation; because, as all metalline and stony salts naturally contain something which prevents their fusion at the fire; so vitriol contains colcothar, or a metallic earth, which, interposing between the saline particles, keeps them from running together. And the stony earth contained in alum, performs the same office in the distillation thereof. It is farther remarkable of vitriol, that tho urged with ever so violent a fire, it seems never to afford all its acid. I once pressed a parcel of it strongly, with a very intense degree of heat, for four days and nights together, so as continually to keep the retort red-hot for all that time; yet, when after this I had suffered the vessels to cool, and coming to take the receiver from the retort, a copious, suffocating, acid fume ascended out of the latter: whence it may be concluded, either that vitriol does not give all its acid in such an operation; or that the

* This colcothar, being calcined in a strong styptic, commonly called *calcanshum rubefactum*, turns blood-red, and becomes the famous

Processes upon Fossils.

caput mortuum, or colcothar, after the action of fire has ceased, draws back again to it self some part of the acid before driven over into the receiver. And, indeed, this suspicion can hardly ever be avoided, but by taking away the receiver in the time of distillation, whilst the vessels are hot: tho this cannot be done without greatly endangering the life of the person who shall attempt it, by the suffocating fumes which are then plentifully rising.

PROCESS CLXXX.

Exhibiting the preparation of Tartar of VITRIOL.

The process.

1. **G**RADUALLY, and at several times, for fear of too much increasing the heat and commotion, mix one part of oil of vitriol with twice its weight of fair, hot water; and into the mixture drop, by degrees, as much oil of tartar, run per deliquium, as will serve to saturate the acid liquor: at each affusion a great ebullition will be made; and after this ceases, or the exact point of saturation is gain'd, a white saline matter, not easily soluble in water, will be precipitated to the bottom of the containing vessel: then the liquor that swims above it, which is of a saltish, but not sharp taste, being first diluted with more hot water, then decanted, filtred, and exhale'd to a pellicle, will, in a cold place, shoot into white crystals, that are neither acid nor alkaline, in figure perfectly resembling genuine vitriol, as we before observ'd of sea-salt; but having no manner of colour, unless some metalline part adheres thereto. And this salt, thus prepared, is called tartar of vitriol; and appears to be no more than a regeneration of that native fossil, or the saline part thereof.

Directions relating thereto; with its physical and medicinal uses.

2. The purer the oil of vitriol, and oil of tartar employ'd in this experiment, the purer the crystals appear. And great care should be taken not to make the salt too acid, when it is design'd for medicinal uses, as it would be by withholding the proper quantity of the oil of tartar. But when the proportion is exactly hit, these two very sharp and opposite liquors unite into a harmless, neutral, mild, and inoffensive salt, tho much more ponderous than nitre or sea-salt; to which ponderosity its superior medicinal virtues, above other salts, appear to be considerably owing, when it comes to mix with the blood and juices: and on this account it is reckoned more effectually aperitive than they. And indeed it admirably, and particularly serves to deterge the vessels of the body, cleanse and disburden the first passages, and open obstructions: it also dissolves so powerfully, that it has gained the name of the universal digester. It may be taken, for these purposes, from five to thirty grains, in a mess of broth, or the like. And hence we are furnished with another clear instance, that one exceeding sharp and violent liquor may so correct and mortify another, as to render it innocent, tho of it self it were destructive to the body; and consequently, that two strong poisons may be antidotes to each other. Thus for instance,

instance, a small quantity of mercury sublimate, taken into the body, would of it self prove suddenly mortal, on account of the acrimony it has from the acid of the sea-salt that enters its composition; whereby it might, in the space of a few minutes, corrode and eat away the membrane which lines the stomach, and cause a gangrene in the part: but if a proper quantity of oil of tartar, made *per deliquium*, be drank immediately after it, this will presently draw to it self, and absorb the acid of the sea-salt, and thereby turn it to sea-salt again, which is no way mischievous to the body; and at the same time suffer the calx of the mercury to remain of an innocent nature; whence the person would receive no harm. And here we may draw this general and useful conclusion, that salts do not act in the body according to what they are at the time they were taken; but according as they meet with other salts, which determine their action in the body. So that it is very unsafe and difficult to assign the action of some medicines given together in composition; or even tho given the one some time after the other.

3. This process, also, gives us to understand the nature of that acid which, in the mines, dissolves metalline bodies into vitriolic substances; and that the metal in this case acts like the fixed alkali in our present process: for when this acid is joined with iron, it turns that metal into those saline glebes which commonly go by the name of vitriol, or copperas. And if this acid be again, by fire, forced from the metalline part, it leaves a colcothar, that is, calcined iron behind it; tho some portion of the metal it self is also carried up in the operation; from whence proceeds the colour and ponderosity of oil of vitriol. And if spirit of sulphur *per campanam*, be poured to oil of tartar made *per deliquium*, a vitriol will thus also be produced; which seems to prove, that the native acid of mines is of the same nature with the former. And indeed it is probable, that there is but one kind of native mineral acid; which, being joined with iron, gives a green vitriol, and with copper, a blue; with chalk appears in the form of alum, and with oil composes sulphur, and various kinds of bitumen.

The physical doctrine it affords.

PROCESS CLXXXI.

Exhibiting the preparation of Ens Veneris from the Colcothar of VITRIOL.

1. **C**ALCINE the colcothar that remains after the distillation of oil of Hungarian vitriol, in a strong, naked fire, for twelve hours, or longer, till it becomes a light powder, of a deep red colour; then take this powder from the fire, and boil it with fair water in a glass vessel; pour off the water impregnated with the colcothar, and put on fresh, and repeat the operation

tior

Processes upon Fossils.

tion till the liquor comes off as clear and insipid as it was poured on. Let the dulcified powder now be dried, and then well ground with twice its weight of dry sal-ammoniac; next sublime the mixture with a proper degree of heat; and after a volatile, and very piercing water has risen, red flowers will ascend, in the manner of those of sulphur, and adhere to the sides of the subliming vessel; which being taken out, are what is called *Ens Veneris*.

Its physical use.

2. This process shews us, that a body which has endured the utmost violence of the fire, and still remained fixed therein, may nevertheless be rendered volatile by means of sal-ammoniac: and the same calx, if suffered to remain in the open air, will, by attracting the moisture thereof, form it self, as it were, into vitriol again.

Medicinal virtues of the production.

3. These flowers have been highly valued for their medicinal virtues; and particularly the excellent Mr. Boyle recommends them, from his own experience, as a specific for the rickets in children. By being exposed to the open air, they will run into a liquor, or tincture of copper, which may conveniently be given, by way of drops, in such cases as require the assistance of that metal.

CHEMICAL HISTORY of ANTIMONY.

Introduction to the history of Antimony.

THE stibium of the antients is the antimony of the moderns; being a fossil glebe, composed of an undetermined metal, a sulphureous, and a stony substance. The best is that found in gold-mines, where it is likewise obtained in greatest plenty. When dug out of the earth, it is put into large crucibles, fused at a violent fire, and then poured into cones, or antimonial horns: which makes the common antimony of the shops; the apex whereof is always the best and purest part, as the basis, or broader portion, is the foulest. Sometimes antimony is found to contain veins of a red or golden colour, and then 'tis called male-antimony; but when it is without them, female: tho this difference depends entirely upon the sulphur adhering to it. Among the chemists it goes by various names, as black-lead, philosophical lead, or Saturn, the bath of the king and queen, all in all, &c. In its crude state, or when barely reduced to powder, it is possessed of no purgative or emetic virtue; but if taken in a very large quantity, it gently stimulates the intestines; and is accounted an excellent remedy to cleanse the blood of horses and other cattel. But when added, in the lump or grossly bruised, to diet-drinks, it seems to communicate very little virtue, or scarce more than a common stone, thereto.

P R O C E S S C L X X X I I .

Exhibiting the Solution of ANTIMONY in Aqua regia.

1. **R**EDUCE antimony to gross powder, put it into a warm glass, and ^{The process} pour thereon, at several times, twice its weight of Aqua regia; a violent ebullition will immediately arise, with suffocating red fumes, which are carefully to be avoided, and a considerable heat. After the ebullition is over, the metalline part of the antimony will be found at the bottom, in form of a grey powder; a mass of yellow matter appearing on the top.

2. This operation is termed the humid calcination of antimony; and ^{its use} may serve to shew, so far as the proof will hold, that this semi-metal approaches nearer to the nature of gold than of silver; as being, like gold, dissolvable in Aqua regia.

2. If the powder, into which the antimony is here dissolved, be gently ^{Nature of the} dried at the fire, it becomes most violently corrosive, purgative, and ^{production} emetic, and capable, in the smallest quantity, of causing very great disorders in the body; so that it cannot be given internally with any manner of safety.

P R O C E S S C L X X X I I I .

Exhibiting the method of procuring the Sulphur of ANTIMONY.

1. **T**O the solution of antimony, made with Aqua regia, pour a quantity ^{The process} of fair water; and the yellow matter, mentioned in the last process, will be made entirely to leave the metalline part at the bottom, and float on the surface; so that it may be readily taken off with any convenient instrument. And if this be well washed in several waters, and afterwards melted at the fire, it will appear in the form of sulphur, hardly distinguishable from the common.

2. The separation of the antimony into two distinct parts, a me- ^{Its nature and} talline and sulphureous, in this process, appears owing to that property ^{use} of acid spirits, whereby they readily dissolve metals, but act not at all upon sulphur, which abounding in antimony, is set free when the acid dissolves the metal; this sinking to the bottom, and the lighter unctuous matter rising to the surface. The subsiding powder is so far of a real metalline nature, that being thus freed from its sulphur, it may, by strong fusion, be made into a pure regulus of antimony. And the yellow matter taken off from the surface, is so really sulphur, and so far from partaking of a metalline nature, that it burns with a blue, suffocating flame, and scarce wants any one property of common brimstone. And

to this sulphureous part of the mineral are entirely owing many of its phenomena, as we shall see hereafter. Whoever, therefore, expects any particular virtues from the sulphur of antimony, different from those of common sulphur, will find himself mistaken; how much soever the contrary opinion may have prevailed. And hence we learn, that common sulphur may be intimately united to mineral glebes, or the parts of metalline bodies, and lie concealed, in considerable quantities, therein; so as not to be discovered by the bare action of the fire; tho they may readily, by means of an appropriated menstruum, be made to yield out one third of their own weight of visible sulphur.

P R O C E S S C LXXXIV.

Exhibiting the method of purifying ANTIMONY by simple Fusion.

The process.

1. **B**RUISE a quantity of common crude antimony, and thoroughly fuse it, for an hour, at the fire, in a crucible, without any addition; it will readily run, and at the same time afford white, suffocating, sulphureous, or arsenical fumes, which are to be carefully avoided. Remove the crucible from the fire, and suffer it to cool; frequently shaking it at first to make the metalline matter settle; break the vessel when it is quite cold, and you will find the matter divided into two parts; the uppermost being a brittle scoria, or light spongy dross; but the other a ponderous, metalline mass; which, when separated from the former, is called regulus of antimony per se.

Its physical use.

2. This process shews us another quick method of purging metalline glebes, or ores, of their sulphur; most of which may, at the same time, by simple fusion, be cleared of the stony and other heterogeneous matter that is apt to adhere thereto; the lighter bodies rising to the surface, and constantly leaving the heavier metal at the bottom of the crucible. If you desire to preserve the vessel wherein the matter is fused, pour out the whole, whilst it remains in fusion, into a dry cone or ingot, greased on the inside; which will cause it to come out the easier when it is cold. And if this process be ever so often repeated, there will a new scoria be thrown off; whence the regulus becomes the purer.

P R O.

PROCESS CLXXXV.

Exhibiting the method of purifying ANTIMONY with flux-powders; or the common method of reducing it to a Regulus, at one operation.

1. **T**AKE of good antimony eight parts, of tartar five or six parts, and The process.
of nitre three or four; grind them to powder separately, then mix them well together, and throw them, by a small quantity at a time, into a nealed or ignited, open crucible: at every injection there will be a strong detonation, and a flashing like that of gun-powder. When the mixture is, by this means, all thrown into the crucible, cover it with a tile, and put it into a strong fire of fusion, and make the matter run like water for about half an hour; then remove the crucible from the fire, and pour out the matter into a melting-cone that is dried, greased, and heated for the purpose. Keep knocking the cone a little, to make the metal subside; and after it is cold, beat out the matter; upon which the sulphur of the antimony will be found, mixed with the salts, in the form of a scoria at top, and the regulus, or metalline part, pure and shining like silver, at the bottom; which may be easily beat from the former by the hammer.

2. The quantity of the flux-powders ought here to be proportioned *Directions relating to it.*
to the sulphur contained in the antimony; it being their office and use to dissolve it, and get it away from the metalline part thereof. Great care must be had in throwing the mixture into the ignited crucible; for if the quantity injected at once be too large, and fresh be added before the detonation of the former, it may grow crusty on its outside; in which case, when the internal parts come to be ignited and rarified, the whole mixture might be blown away, and scattered around to a very considerable distance; and thus prove as mischievous as a little mine of gun-powder. And the like care is required to keep the fire equable in its strength, to prevent the matter in fusion from cooling and growing crusty on its surface; which might also be of very bad consequence. No less caution is required in well drying, heating, and carefully greasing the cone, into which the melted matter is to be poured; for if a single drop of water should be lodged therein, it would break the vessel to pieces, and throw them off with a very great violence. And to prevent any ill accident from this cause, it will be proper never to use oil, which always contains some proportion of water; but well purged tallow, or other unctuous substance, that is perfectly free from all aqueous moisture.

3. We have already seen, that antimony is principally composed of *Its doctrine and*
sulphur and metal; whence it will be easy to account for its depura-
tion in the manner of our present process: for both tartar and nitre instantly change to an alkaline nature in the fire, and powerfully attract and drink in sulphur, like fixed alkali, leaving the metal untouched:
whence

whence it is evident that the scoria in this operation is mere sulphur, thus dissolved by the fluxes, and thrown to the top from the heavier metal. And this shews us the general method of purifying all sorts of metalline glebes, or bringing them to a regulus, by means of fluxes, as they are called at the mines; and, in particular, it gives us another method of freeing semi-metals of their sulphur; from which, if antimony could ever be perfectly separated, we might then know what kind of metal it contains: but this is no easy task, tho it may be approximated for ever. And when, by repeated fusions with fresh fluxes, the regulus arrives at a considerable degree of purity, it commonly represents the figure of a star upon its upper surface.

*Virtues and uses
of the produc-
tion.*

4. The scoria found at the top of this regulus is violently emetic, as well as the regulus it self; whereof, if cups or drinking vessels be cast, the wine that is put into them will become vomitive. And of this regulus, cast in moulds, are also made those commonly called the antimonial pills, weighing about eight or ten grains each; one of which being swallowed, will operate considerably both by vomit and stool. And these pills having thus performed their office, and being discharged the body, will serve for the same purpose again and again: whence they have obtained the name of *perpetual pills*. The virtue of this regulus is not, however, inexhaustible, as has been imagined: for by repeated infusions in wine, tho the liquor be made violently emetic at first; yet by degrees it loses its force, and at length ceases to be vomitive.

P R O C E S S C L X X X V I.

Exhibiting the purification of ANTIMONY, by means of salts and metals; or the preparation of the Regulus Antimonii, or Regulus martialis stellatus philosophorum, by four operations.

O P E R A T I O N I.

*The process,
part the first.*

I. **P**UT a proper quantity of pure iron, such as that of the nails where-
with horses are shod, into a strong crucible; set it in a wind-furnace, and when the metal is thorowly ignited, put in double its weight of fine-ground antimony; then make a fire of fusion, and add, by small quantities at a time, something less than half as much dried nitre as there was iron. After every injection of the nitre, wait for the detonation, and prevent the matter from growing crusty on the surface; otherwise it might blow up the furnace. When the whole quantity of nitre is thrown in, and the last detonation is over, cover the crucible with a tile, and surround it with a vehement fire, to make the matter flow, like water, for some time; lastly, pour it out into a melting-cone, first heated, dried, and greased, as directed under the last process; upon which the metalline

metalline part of the antimony will be found at the bottom, and the lighter scoria at the top, as is there also mentioned.

2. It is the nature of iron in fusion to be strongly attractive of sulphur, as we formerly observed, when run together into one mass; so that in this operation the iron first powerfully absorbs and dissolves the sulphureous part of the antimony, and turns with it into a light crocus; upon which the nitre being fulminated, and causing a strong flux of the matter, the metalline part of the antimony falls by its own superior gravity to the bottom. And as in this case the iron attracts the sulphur much stronger than the fixed alkali, or the fluxes used in the preceding process, it appears plainly that the antimony must obtain a greater degree of purity by this operation, than by that. And this is the method used at the mines, of purging metals of their sulphur, or extracting from them their sulphureous soul, as the artists affect to speak; who, therefore, generally call iron the magnet of sulphur. The scoria thrown to the surface in this operation, is violently emetic, and will presently run *per deliquium* in the open air. The regulus, likewise, if infused in wine, will readily communicate a vomitive faculty thereto.

Its nature;
with that of the
production.

OPERATION II.

3. PUT the regulus gained by the preceding operation into a new, clean crucible, and set it in the fire again; when the matter flows, as it readily will, add to it as much fine powder of crude antimony as there was nitre used before; and when these run, put to them, by degrees, the same quantity of well-dried powder of nitre as was added in the first operation, and with the same caution as is there given. After the matter has, by a strong fire, been made to flow as before, pour it out into a cone, dried and prepared to receive it; by which means there will again be obtained a regulus and a scoria; but a regulus much purer than the former, and containing no iron; all that remained thereof being here joined to the fresh, additional antimony.

The process;
part the second.

4. The regulus of this second operation must therefore partake more of the nature of antimony than the former. The scoria also of this second process, consisting of nitre, sulphur, and iron, are wonderfully sharp and vomitive, of a more golden colour than the first, which is almost black, and will readily run in the air.

Nature of the
production.

OPERATION III.

5. To the regulus of the second operation, put into a new crucible and melted again, add the same quantity of dry, pulverized nitre, in the same manner; which also will make a kind of detonation: this being over, let the matter flow in a strong fire, and then pour it into a cone, as before. And by this means the regulus will again become much purer, more metalline, or approaching more to silver, than the former.

The process;
part the third.

Nature of the
production.

6. The scoria, likewise, in this operation, is of a gold-colour, and in the air will run, with great facility, into a yellow or golden liquor, or oil, that is exceedingly corrosive and still emetic; as also is the regulus it self, either taken alone, or infused in wine.

OPERATION IV.

End of the process.

7. Take this third regulus, put it into a new crucible, melt and fulminate it again with the same quantity of nitre; then make up a stronger fire around it than was used in the preceding operations, or the strongest the furnace will bear; and when it has thus remained for a quarter of an hour, at least, in fusion, pour it into a melting-cone as before, and there will be obtained a very pure and ponderous, metalline regulus of antimony, purged of all its external sulphur, but still retaining enough of the internal to render it brittle: and if the operation was well performed in all its parts, the production will exhibit the resemblance of a star upon its surface, and more internal parts.

Nature of the
ultimate production.

8. This regulus seems to want nothing but malleability to make it an excellent, white, sonorous, shining metal; being something like silver in its colour and appearance; tho not strictly referable to any of the metals, or other known bodies. This is the starry regulus of the philosophers, which some of them have esteemed as the basis of the grand secret. The adept, in their language, tell us to procure the mercury of antimony *per se*, "wherein if gold be put, it dies, and rises again the "glorious stone." But how to free antimony of all its sulphur, so that nothing but perfect mercury may remain, I frankly acknowledge my self ignorant: for tho I have purified it over and over again, yet it constantly remained brittle: nor could I ever render it malleable by mixing it with iron, copper, mercury, or any other metalline body. *M. Homberg*, however, tells us he knew the method of doing it; which must needs be a very valuable secret. The scoria cast off even in this fourth operation is more fiery, and apt to run in the air, but less emetic, than any of the former. And indeed the vomitive virtue of the scoria always decreases as the operation is repeated.

P R O C E S S CLXXXVII.

Exhibiting the preparation of the golden Sulphur of ANTIMONY.

The process.

I. TAKE the scoria of antimony, cast off from the metalline part, in the preceding processes; boil it in fair water, and filtre the hot decoction, which will thus give the sulphur of the antimony, dissolved by the alkalinized nitre, in the form of a red and scumless lixivium. To this solution, add a sufficient proportion of distilled vinegar, or any other acid, and immediately the whole will coagulate, change to a brown colour, emit an intolerable stercoraceous odour, like that of human excrement, and precipitate a red powder. Then

this whole coagulated mass, being washed by repeated affusions of fair water, till the liquor comes away as scentless and insipid as it was poured on, and afterwards gently dried, becomes a red powder, called the golden sulphur, or precipitate of antimony, either on account of its own colour, or the yellow one it gives to glass, metals, and other kinds of bodies.

2. If the decoction of the scoria of antimony be permitted to stand a few hours, before the spirit of vinegar is poured thereto, it will almost wholly concrete into a very thick mass. And as soon as ever the vinegar is added, there ensues a most disagreeable scent, which may be avoided by placing the containing vessel under a chimney. *Observations thereon.*

3. To understand the reason and nature of this process, we must observe that the nitre, fused along with the antimony, turns alkaline in the fire, and therefore dissolves the sulphur; and thus makes it soluble also in water, leaving it precipitable with acids, which destroy the force of alkalies. *Its rationale.*

4. This precipitate, or golden sulphur of antimony is emetic, as well as the regulus of antimony, tho in a somewhat less degree; whence it appears, that the vomitive virtue of antimony is lodged as well in its sulphureous as its metalline part. Being given in the quantity of three or four grains, it either proves emetic, cathartic, diuretic, or sudorific, according as its force happens to be determined. *Virtues and uses of the production.*

P R O C E S S CLXXXVIII.

Exhibiting the preparation of the Crocus or Liver of ANTIMONY.

1. **T**AKE equal quantities of antimony, purified by simple fusion and of good salt-petre; grind them to fine powder, mix them together, and cast of the mixture, by small parcels, into an ignited iron-ladle: the powder will at every time, flash and go off with a force like gun-powder; and by this means alone, when the last detonation is over, the matter will be turned to a dark, or shining liver-coloured substance, called by the name of Crocus, or Hepar antimonii. *The process.*

2. This process should be performed in an iron-ladle, and by repeated injections of the powder, on account of the violence of the detonation, wherein it greatly resembles gun-powder, the ingredients whereof are nitre, sulphur, and coal; the two former of which are contained in the present mixture, the metal supplying the place of the other. *The cautions it requires.*

3. The crocus it self is most violently emetic, in a very small quantity; the tenth part of a grain being unsafe to venture upon for internal use; tho it has sometimes been employed in a larger dose. And in case it proves too strong, the best way to stop its vehemence, and prevent farther ill-effects, is to order warm vinegar, sweetened with sugar, to be drank in the quantity of three or four ounces. But it seems *Virtues and uses of the production.*

NOW

Processes upon Fossils.

now to be in difuse ; the *crocus metallorum*, as it is called, being given with much more safety. This *crocus metallorum* is no more than the liver of antimony it self, ground and well washed by repeated affusions of warm water, and dried to a powder again. It is also called *Crocus Antimonii*, *Terra sancta Rulandi*, *Terra aurea*, *Terra rubra*, &c. a single grain whereof, tho thus mitigated and edulcorated, will operate so violently, both by vomit and stool, that it is sometimes hard to stop it, or prevent dangerous consequences from its use : for which reason, it is commonly infused in wine, and the clear part of the infusion alone prescribed internally. One ounce of this edulcorated powder being put to thirty or forty times as much of any wine that is not too acid, and gently boiled with it in a tall glass, or let stand for four and twenty hours, the filtered liquor is accounted an excellent, pleasant, and tolerably safe emetic, given from two drams to as many ounces. And this was the great secret of *Rulandus*, who called it his golden tincture ; but is now the common emetic wine of the shops ; and which, it is vulgarly thought, does not lose of its virtue, if fresh wine be added to the faeces, or powder at the bottom of the containing vessel : but this is a great mistake ; for the first parcel is always the strongest or most vomitive, and the succeeding ones gradually weaker ; so that the third infusion will scarce operate at all. The powder, thoroughly edulcorated, or freed from its salt by being boiled in water, and with an equal quantity of sugar-candy, made into fine powder, is greatly commended for taking off all inequalities, films, specks, or pearls in the eyes ; a small portion thereof being blown into them with a quill, twice or thrice a day. And this was the secret of a famous oculist at *Amsterdam*.

PROCESS CLXXXIX.

Exhibiting the preparation of a mild Emetic from ANTIMONY.

The process.

1. TAKE of antimony, purified by fusion, one part, and of nitre two parts ; reduce them to powder, mix them, and throw the mixture by degrees into an ignited iron crucible or ladle ; upon which it will instantly flash and explode like gun-powder, and at last leave a greyish coloured mass, inclining to yellow, behind ; which of it self, or being edulcorated by repeated affusions of water, becomes a mild and safe emetic.

Virtues and
uses of the pro-
duction.

2. This preparation is a much more gentle emetic than the *crocus metallorum*, and may, for that purpose, be given from one grain to eight or ten ; tho it will not always operate by vomit, especially in such as have been used to the sea, or whose bodies abound with acid ; but sometimes takes downwards. And if somewhat more than two parts of nitre be, in like manner, added to two of antimony, the effect of the preparation will be of the same kind upon the body, tho much milder than the former, or equal to a smaller dose thereof ; and being taken in
the

the same dose, it will pass the stomach, and only excite a nausea, and perhaps a reaching, for a few hours, but rarely proceeds to a full vomit, unless the patient in his constitution be greatly inclined thereto. Hence, by stimulating the intestines, it proves an excellent medicine in all those distempers which require the first passages to be cleansed, or obstructions therein to be opened. It is, therefore, good in case of worms and phlegmy matter lodged in the *prima via*; tho on account of the long continuance of the nausea it creates, it proves troublesome enough to the patient.

PROCESS CXC.

Exhibiting the preparation of diaphoretic ANTIMONY with nitre.

1. **T**O one part of antimony, purified by fusion, and reduced to powder, add The process. three parts of good nitre, and grind them well together in a stone-mortar; throw the mixture, at several times, into an ignited crucible, and it will fulminate like gun-powder, tho in a less degree than in the preceding processes; and being afterwards kept in fusion, for a quarter of an hour, it will turn into an almost white mass, called *Antimonium diaphoreticum nitratum*, or diaphoretic antimony with nitre; being destitute of an emetic virtue.

2. The powder ought not here to be thrown all at once into the crucible, because in that case some metalline part of it might happen Directions relating to it. not to be calcined; whence the medicine would become emetic, contrary to the design of the process. Nor ought the matter to be detained in the fire longer than a quarter of an hour; otherwise the antimony would turn to a regulus, and fall metalline to the bottom of the crucible.

3. This is the diaphoretic antimony that I constantly use in my practice; and it will not, I find, prove vomitive, tho given without being washed, in the quantity of a dram at once; but only operate by sweat. Virtues and uses of the Preparation. But *Basil Valentine*, who first described the medicine, imagined I know not what emetic virtue to adhere to the nitre; and therefore orders it to be frequently washed in water, to free it from its salt. But this is perfectly needless; for neither has nitre any vomitive faculty, nor does the diaphoretic antimony operate in that manner, tho used as it comes from the crucible, without any ablution. Yet the inventor, not content with ablution, orders it to be afterwards calcined, and then fixed with alkalized alcohol; as supposing that its emetic virtues were pinned down by such treatment: but this method would entirely destroy its action, and render it insignificant in the body. When prepared in the manner of the present process, the nitre and the sulphur of the antimony become a kind of *sal polychrestum*; the metalline regulus being at the same time reduced

Processes upon Fossils.

reduced to a white calx; which, as well as the sulphureous part of the antimony, is deprived of its emetic property by the nitre in the operation: whence we see that the vomitive poison of antimony may be corrected by suitable quantities of nitre, and degrees of calcination, and the mixture thus be converted into almost all kinds of medicines. Thus antimony, calcined with an equal proportion of nitre, becomes a violent emetic and cathartic; with twice its quantity of the same, a mild emetic; with above twice its weight thereof, a stimulating purgative, that operates upon the stomach so far as to give a nausea; and with thrice its quantity of nitre, a kindly diaphoretic; which may be given in any dose from a grain to a dram. Ordered in the quantity of ten or twelve grains, four or five times a day, with any convenient liquor, it is an excellent medicine in the measles and small-pox, and prevents the too great suppuration of the pustules. And in all respects it seems to have perfectly the same virtues with *sal polychrestum*, and no other; for I could never observe it had those which *Sylvius* attributes thereto.

P R O C E S S CXCI.

Exhibiting the preparation of the common diaphoretic ANTIMONY; or Antimonium diaphoreticum dulce.

The process.

1. **R**EDUCE the diaphoretic antimony of the preceding process to impalpable powder; boil it in fair water; filtre the decoction, and a white powder will be left in the filtre; which being well washed by repeated affusions of fresh water, and gently dried, is the dulcified, or common diaphoretic antimony of the shops.

Nature of the production.

2. The powder thus obtained, is a mere metalline calx of antimony, reducible to a regulus by the fire, and entirely destitute of all medicinal virtues, or serving only to load, oppress or choak up the body by its inactivity and weight*. That this is fact, I have found by many experiments; and knew a noble lady, who was, by the frequent use thereof, thrown into a languid state, with pains in the stomach, of which she afterwards died. When the body came to be opened, her stomach and intestines were found crufted over, or lined on the inside, as it were with potters-clay, by this powder sticking and being there inviscated by the native mucus of the parts. Yet some there are, who persuade them-

* It happens unluckily in medicine, that what some physicians positively assert, others as positively deny; and both from what is commonly appealed to as decisive, experience. *Antimonium diaphoreticum* is by many celebrated physicians expressly declared medicinal, and by one in particular of singular efficacy in delirious cases. *Ad delirium*, says he, *maximè prodest Antimonium diaphoreticum, per se sumptum: quod licet à quibusdam medicis ut effœta calx æstimetur, sæpè tamen, & semper per se, optato successu, non modo in vigiliis, sed & in delirio præscripsi.* And again, *Antimonium diaphoreticum, cujus efficaciam tum ad pustulas expellendas, tum ad sedanda deliria sæpè expertus sum.*

selves

selves that this preparation has wonderful virtues, and, like a magnet, attracts to it self all that malignity, or poison of an antimonial nature, which shall at any time be lodged in the body; the like whereto, they imagine was contained in the antimony it self, before it underwent this operation; but that it is thereby perfectly devided and freed from it. And hence *Tachenius* recommends it as an admirable anti-pestilential remedy. This notion seems to have sprung in the minds of some chemists, from the property which antimony has of purifying metals; after which manner, they fondly conceived it would also purify the blood: tho, to do the former, it requires to be fused in a violent fire.

PROCESS CXCH.

Exhibiting the preparation of Nitrum Antimoniatum, or the diaphoretic Nitre of ANTIMONY.

1. **E**XHALE the strong decoction, or filtered solution, of the preceding process, over a gentle fire, to dryness; and there will be left behind a salt, like the *sal polychrestum*, composed of nitre and the sulphur of the antimony, called *nitrum antimoniatum*. The process.

2. If the decoction be here made strong, and filtered hot, it will dissolve and contain all the nitre that was united to, and fixed the diaphoretic antimony, and absorbed the sulphur; whence the salt obtained by the exhalation of the superfluous moisture, must needs be a kind of *sal prunella*, or *sal polychrestum*. And accordingly it is aperitive, cooling, diuretic, and diaphoretic; whence it becomes useful in inflammatory fevers, the small-pox, measles, &c. and capable of opening obstructions without stimulating or fretting the parts. To answer these ends, it may be given in the quantity of a dram, with very great safety and success. The solution or *lixivium* it self, may also be taken to advantage, and will perform all that can be expected from the diaphoretic antimony prepared with nitre, without at all oppressing the body by its weight like that; which is owing to the metalline part it contains. When, therefore, the chemists throw away this *lixivium*, in the preparation of the common diaphoretic antimony, they throw away an admirable medicine, and save a very bad one. Nature and Virtues of the production.

PROCESS CXCV.

Rr

PRO

PROCESS CXIII.

*Exhibiting the fix'd Sulphur of ANTIMONY.**The process.*

1. **T**O the strong and clear lixivium of the preceding process, pour a sufficient quantity of good distill'd vinegar, to make a thorow precipitation; upon which, the liquor will immediately become turbid and milky, and let fall a fine, copious, white powder, or precipitate, to the bottom of the containing vessel. This powder being, by the filtre, separated from the liquor, well wash'd by repeated affusions of fair water, and gently dried, is Tachenius's fix'd, anti-pestilential sulphur of antimony.

Chemical rationale thereof.

2. The nature and reason of the operation will appear from remembering that antimony contains sulphur; that nitre is in the fire convertible into fix'd alkali, by any inflammable body; and that fix'd alkalies are solvents of sulphur, which is afterwards precipitable by acids.

Nature of the productions.

3. The turbid liquor of this process is call'd the milk of antimony; and is said to be an excellent medicine in case of poisons, and all diseases proceeding from them. It is certainly possess'd of an alexipharmic virtue, on account of the Vinegar, and nitre, both which are good medicines in acute and pestilential cases, and here unite with the sulphur into a *sal polychrestum*. For the same reason the liquor that passes the filtre is also of great medicinal virtues; being wonderfully aperitive, and good in all hot, acute and malignant diseases; and the better for being discharg'd of that indolent white powder or precipitate; for the fix'd sulphur it self is only the most sluggish and unactive part of the sulphur, precipitated by the vinegar, along with the metalline calx of the antimony, that was join'd to the nitre; and consequently has no considerable virtues as a medicine. I have given it in large quantities, but cou'd never find any good effect it produc'd: yet Tachenius extols it as a noble remedy against the plague; but he was certainly mistaken, and unjustly ascrib'd the good effects he saw it have in that distemper to this sulphur, which in reality were owing to the vinegar he gave along with it; which indeed is an admirable anti-pestilential remedy. In effect, this preparation ought of it self to be esteem'd no more than an indolent precipitate, or calx, as I have found by a large number of experiments.

PROCESS CXIV.

*Exhibiting the preparation of the Butter, or icy Oil of ANTIMONY.**The process.*

1. **T**AKE equal parts of common, crude antimony, not too much purified, and of new and shining Venetian corrosive sublimate; grind them separately to fine powder, in a glass mortar, set in a dry cool place, and afterwards mix

mix them well together, for a considerable time, with great care that none of the noxious dust gets up the nostrils, or enters thro' the mouth into the lungs; then cautiously put this powder into a large coated retort, capable of containing four or five times the quantity, so cut as to leave a very large aperture, and the remaining part of the neck extended somewhat long and strait; lute on a very large receiver, and distil in a sand-furnace, with due degrees of fire. A gentle heat, being continued for the first hour, will bring over a small quantity of a sharp, thin, pellucid caustic water; when the fire is a little increased, there rises a white oily liquor, which afterwards congeals to a thick unctuous substance, called the icy oil, or butter of antimony, and often adheres to the neck of the retort; where, if it be detain'd, it ought to be melted down into the receiver by the application of live coals near that part of glass where it lodges: when by gradually raising the fire, this butter is all come over, and red or dark-colour'd fumes appear, the receiver must be changed, for fear of fouling what has already ascended, and now, in the cold, appears like ice, but melts by heat into a kind of oil. Then increase the fire to its greatest degree, and add likewise a fire of suppression; continue thus, for two or three hours, till the retort is almost red hot; by which means volatile red fumes will first ascend, which are carefully to be avoided; then there will be made to sublime, a variously colour'd matter, sticking to the neck of the retort; some globules of quick-silver passing into the receiver. When the vessels are cold, break the retort, and an imperfect cinnabar of antimony will be found in the neck; which tho' it may seem black, almost like athiops, will, when pulverized, appear of a reddish colour; and at the bottom a small quantity of antimony; all the butter having pass'd into the receiver.

2. This process should only be perform'd with small quantities of the ingredients, to prevent the mischief which might otherwise arise in case of an accident; as the blocking up of the neck of the retort by the butter. The antimony and sublimate are by all means to be mix'd and ground in a glass mortar; for they would corrode one of iron or brass, and thence make a kind of butter in the trituration; during which the effluvia must cautiously be avoided, otherwise grievous vomitings, a salivation, and the worst of symptoms will arise in the body; nay, these effluvia are capable of affecting the brain and lungs to such a degree, as to render a man for ever languid, and unfit for the offices of life. The retort likewise must by all means have a very large aperture; because it frequently happens that the butter ascends all at once, choaking up the neck of the glass, and causing it to burst with great violence; to which accident a very famous chemist of this university ow'd his death: for the corrosive vapours being by this means instantly dispers'd thro' the air, they at once constringe the lungs, and either bring on an incurable peripneumonia, or prove suddenly mortal. The quantity of cinnabar obtain'd in the process, will constantly be proportionable to the degree of impurity in the antimony; for if the regulus of antimony were here used instead of antimony it self, scarce any cinnabar at all would be obtain'd; this always proceeding from the sulphureous part of the mineral, join'd with the mercury of the corrosive sublimate.

The caution it requires.

Its doctrine and use.

3. We are here taught a general method of rendring metallic bodies volatile, or reducing them to the form of a butter : for the acid spirit of the sea-salt contain'd in the corrosive sublimate, acts strongly upon, and dissolves their metalline parts; whilst their sulphur, now united to the revived mercury, is converted first into an athiops, then into a cinnabar; leaving the regulus of the metal, changed and volatilized by the acid, to be carry'd over into the receiver by the force of the fire : for the butter of antimony is nothing more than the regulus of that semi-metal alter'd in its nature and form by the sublimate. And hence antimony, which of it self is tolerably fix'd in the fire, may be render'd exceedingly volatile; for if this butter be again committed to distillation, it will rise as easily as spirit of wine. But this process does not only hold true in antimony; it is really universal with regard to metals. Gold it self, which is said to lose nothing of its weight tho detain'd for a month in a glass-house furnace, may thus be render'd volatile, by distilling it with an equal quantity of the regulus of antimony, and twice as much corrosive sublimate. And in the same manner there may be made a strange kind of butter with copper. So likewise with one part of tin, and two parts of mercury-sublimate, there will arise in distillation that strange suffocating, perpetually fuming, and exceedingly corrosive liquor mention'd by Mr. Boyle.

Nature and use of the production.

4. This butter of antimony is a violent poison, used internally; for it presently burns and corrodes all the parts it touches: on which account 'tis employ'd as a caustic by the chirurgeons: and I know no other use of it in medicine; tho some imprudently venture to prescribe it internally. And in like manner, the butter of any other metal, prepar'd in this manner is violently corrosive.

P R O C E S S C X C V.

Exhibiting the conversion of the Butter of ANTIMONY into Oil.

The process.

1. **W**ARM the butter of antimony of the preceding process at a gentle fire, taking care to avoid the fumes it affords, and it will melt and run like oil; whilst it remains in this state, pour it into a clean glass retort, and with a gentle heat in sand, and the like apparatus and caution as before, distil it to dryness. The matter that comes over, will be much more volatile and liquid than in the foregoing process; tho still assuming an icy form in the cold; whence it is called rectify'd butter of antimony; but if it be distill'd or rectify'd again in the same manner, it will turn to a perfectly transparent fluid, and exceeding corrosive oil.

The caution to be observ'd therein.

2. The vapour at any time ascending from the butter of antimony in this process, is to be avoided with the utmost caution; being so highly poisonous, as, if taken in at the nose or mouth, to prove instantly mortal.

3. The

3. The oftner this oil is distill'd over, the more fluid, subtile and volatile it always becomes; from whence we learn the surprizing power that salts have of changing metalline bodies, and totally converting them from their inactive, harmless, fix'd and solid nature, into most subtile, volatile, and violently poisonous fluids. *The doctrine it affords.*

4. This oil is chiefly used by chirurgeons, as a caustic, to take off warts, small cancers, schirrous tumours, &c. which it does after the manner of *Lapis infernalis*; tho at the same time it causes a greater inflammation than that. When digested with about thrice its own weight of alcohol, it makes the purple tincture of antimony; which was the secret of the excellent Mr. Boyle, and highly valued in England, and by him communicated to the admiral du Quesne; a single drop or two whereof being taken in any convenient vehicle, works well by vomit. *Virtues and uses of the production.*

PROCESS CXCVI.

Exhibiting the precipitation of Butter of ANTIMONY into Mercurius Vitæ.

1. **P**OUR a sufficient quantity of warm rain water upon butter of antimony, and it will all immediately precipitate into an exceeding white and ponderous powder; which being, by the filtre, separated from the liquor, and well wash'd by repeated affusions of warm water till it becomes insipid, and then gently dried, it becomes what is improperly called Mercurius Vitæ; being in reality no more than a fine calx of antimony, without any mercury at all. *The process.*

2. This antimonial powder, otherwise call'd algarot, remains fix'd in a pretty strong fire, but is wholly reducible by a greater into regulus of antimony; which shews its metalline nature. And the reason of the process seems to be this; that the acid spirit of the sea-salt contain'd in the mercury-sublimate, having been set loose from the mercury it before dissolved, fastens upon the regulus of antimony, and turns it to a butter; when, the menstruum being weaken'd with water, the regulus can no longer remain suspended in the liquor, but falls, in the form of a powder, to the bottom. Whence we see, that by means of water alone, a solid, ponderous, and fix'd body may be instantaneously procur'd out of a fine, volatile fluid. *Nature of the production; with the rationale and doctrine of the process.*

3. The water here first poured upon the butter of antimony, when filtered, is an excellent menstruum, or spirit of sea-salt, tho improperly called the philosophic spirit of vitriol, and capable of dissolving gold into *aurum potable*; for it contains the strong acid spirit of the sea-salt that enter'd the composition of the mercury-sublimate: which, however, is here wonderfully changed in its nature, by mixing with the quick-silver; so that scarce any known menstruum can, for power, be compared therewith; as performing those strange things which the illustrious Boyle relates of his menstruum

menstruum peracutum; especially when evaporated to about a fourth part of its original quantity.

*Virtues and
uses of the pro-
ductions.*

4. The edulcorated precipitate it self is violently emetic, in the quantity of two or three grains; but may be depriv'd of that virtue by calcination. The filtred solution, however, is not vomitive, but may successfully be used internally as a good spirit of salt; for it seems to have all the virtues thereof.

P R O C E S S CXC VII.

Exhibiting the preparation of Bezoar Mineral from Butter of **ANTIMONY.**

The process.

1. **T**O a quantity of rectify'd butter of antimony, contain'd in a glass vessel, gradually drop of spirit of nitre till the effervescence they make together entirely ceases, and there will a perfect dissolution be made: then dry the matter by a gentle fire, and again pour spirit of nitre to the remainder; dry it, and repeat the operation one time more: afterwards put the remaining powder into a crucible, and set it in a strong open fire till it becomes almost red hot; detain it in this state for half an hour, and what remains will be a white ponderous powder, call'd bezoar mineral*.

*Its rationale,
and uses.*

2. In this process we are to conceive that the metalline part of the antimony, dissolved and brought to a butter by the spirit of salt in the mercury-sublimate, becomes an *Aqua regia* by the affusion of spirit of nitre, which thorowly dissolves the regulus of antimony with a great effervescence; but when the acid is here driven away by the violence of the fire, nothing remains behind but the sluggish and calcined metalline part of the antimony; which tho dignified with the name of mineral bezoar by *Basil Valentine*, is destitute of all medicinal virtues, and only serves to oppress the body by its gravity; being perfectly indigestible therein. And in this it somewhat agrees with the bezoar-stone, whence it seems to have borrow'd its name. *Sylvius*, upon the authority of *Basil Valentine*, the first inventor of this preparation, ventur'd to introduce it into medicine; and frequently gave it with very bad success. Yet many are to this day persuaded, with him, that it is possess'd of wonderful antidotal virtues; as being obtain'd innocent and harmless from that violent poison, butter of antimony; whence they conclude it must needs have a magnetical power of attracting to it self, like the bezoar-stone, all the poison that happens to be lodg'd in the body: but tho, in reality, it has no medicinal virtue at all, yet it affords us an admirable experiment for solving chemical phenomena, and discovering the nature of fossils. Some there are, indeed, who imagine it to be emetic; and so it is when

* Spirit of nitre several times drawn off | this process, is the *menstruum peracutum* of
from the butter of antimony, as it may be in | Mr. Boyle.

not well prepar'd; but not otherwise. The experiment shews that acids may make a violent ebullition with acids, as well as with alkalies, and undergo surprizing changes thereby; for butter of antimony and spirit of nitre are both violent acids. And if the preparation it self be press'd with a violent fire, it will afford the purest regulus of antimony that can any way be procured.

P R O C E S S CXC VIII.

Exhibiting the preparation of Cinnabar of ANTIMONY.

1. **G**RIND to fine powder the imperfect cinnabar which rises in the distilla-^{The process.} tion of butter of antimony, according to the hundred and ninety fourth process, and sublime it a second time, with proper degrees of fire, in a new coated retort, till the bottom thereof be almost of a red heat: the cinnabar will now rise in the neck of the glass much purer than before; and when ground will appear of a beautiful red colour, like minium.

2. The chemical rationale of the process is this. Corrosive-sublimate be-^{Its chemical rationale.} ing no more than the acid spirit of sea-salt joined to the body of quick-silver; and sulphur abounding with a coarse external sulphur, not to be touched by acids; the metalline part of the antimony is here dissolved, like gold in *Aqua regia* or spirit of sea-salt; upon which, the quick-silver is again set loose or revived, as being depriv'd of the acid that before held it dissolved; so that the sulphur of the antimony readily lays hold thereof, and, by means of the heat, converts it into æthiops mineral, which becomes cinnabar by sublimation: from whence the fluid mercury may again be recover'd pure, by grinding it well, and distilling it, with twice its quantity of fix'd alkali, or iron, which dissolves and strongly absorbs the body of the sulphur.

3. Whether this cinnabar of antimony be possessed of those virtues as-^{Virtues of the production.} cribed to it by *Helmont*, I have not experienc'd; but it seems probable to me that it will constantly produce the same effects with common factitious cinnabar; as being produced in the same manner with that.

P R O C E S S C X C I X .

*Exhibiting the preparation of the Emetic Flowers of ANTIMONY.**The process.*

1. **T**AKE of antimony dissolved, and render'd corrosive by Aqua regia, and exhale it over a gentle fire till it is perfectly dry; then reduce it to fine powder, and grind it well with an equal quantity of pure sal ammoniac; put the mixture into a very wide-mouth'd and capacious, but low glass cucurbit, to which fit a very large perforated head; lute it on well, and bury the cucurbit up to its neck in sand; then light up the fire, and increase it by degrees: what comes over first will be an aqueous acid liquor; after this, white fumes will arise; when these appear, take away the receiver, lightly cover the nose of the glass-head with paper, and raise the fire, which will cause the antimony to sublime, and fix it self to the top of the glass in various colours; leaving only a small quantity of faces of the nature of sea-salt, behind. When the glasses are cold, take out the variously colour'd matter in the head, and preserve it under the name of emetic flowers of antimony.

The caution it requires.

2. The orifice of the head ought not to be closed in this operation before the white fumes ascend, because the vessels might otherwise break. Almost the whole body of the antimony is here sublimed into what, on account of its many colours, is called the flowers thereof; tho it also happens to resemble flowers in its figure.

The doctrine it affords.

3. This process shews us the art of what the chemists call killing and reviving; among whom killing is the same as fixing, or corroding; and reviving the same as subliming, or opening the bodies of things. We are also hence taught a method of subliming, or opening the bodies of metals, and of producing various colours by thus unlocking the texture of one black body; which when treated with a violent fire, becomes of a red colour; but if urged with a strong one, turns of a brown; antimony thus seeming to have the character of the philosophical mercury.

Medicinal virtue of the production.

4. These flowers of antimony prove strongly emetic, in the dose of a single grain; and if wash'd and edulcorated with warm water, so as to become perfectly insipid, and appear either grey or brown, they still retain this property; and are then called *Helmont's* emetic flowers of antimony.

P R O C E S S C C.

Exhibiting the preparation of **Helmont's Antimonium diaphoreticum, or the fix'd Flowers of ANTIMONY.**

1. **T**AKE one part of the dulcified flowers of antimony, prepared after The process. the manner of the preceding process, and three parts of pure, dry nitre; grind them well together; and throw the mixture, by degrees, into an ignited crucible, and it will fulminate like common diaphoretic antimony with nitre, but less strongly; and thus turn to what is called fix'd flowers of antimony; which being well wash'd in several waters, ground fine, and twice or thrice deflagrated with alcohol of wine, makes the Antimonium diaphoreticum Helmontii, that has no manner of emetic virtue.

2. These fix'd flowers of antimony are apt to prove vomitive, unless they be well dulcified, or several times well wash'd with water; especially in such constitutions as are easily moved that way: but if taken in the quantity of two scruples, or even a dram, along with vinegar or other small acid, they only prove sudorific. *Helmont* gave this preparation the name of *antimonium diaphoreticum*, who is large upon its virtues; and in particular recommends it for the cure of all tertian and quartan agues: but I could never, upon repeated trials, find it answer the character he gives it. Being given in the dose of fifteen or twenty grains, along with any emetic, sudorific, purgative, or diuretic, it will have its force and virtue determin'd by them, and operate successfully enough. And thus it may do service in distempers whose cause is seated in the second stage of circulation, and be made to purge and purify the blood; as also to cure agues, when the cause thereof is not fix'd, but movable. Nature and virtues of the production.

P R O C E S S C C I.

Exhibiting the preparation of **Helmont's purging Flowers of ANTIMONY.**

1. **T**AKE six parts of *Helmont's* diaphoretic antimony, well wash'd from its adhering nitre, rosin of scammony three parts, and cream of tartar one part; grind them together to a fine powder, which is called the purging flowers of antimony.

2. This preparation differs but little from the *Pulvis Comitissæ Warwicensis*, Medicinal virtues and uses of the production. or *Cornachini*; *Helmont's* diaphoretic antimony here, supplying the place of the common in the other. This is however an excellent cathartic in all dropical cases, and such distempers as are curable by purging. Being given from eight or ten grains, to thirty or forty, three hours before the paroxysm of an intermitting fever, it seldom fails to cure it at the first taking;
S f

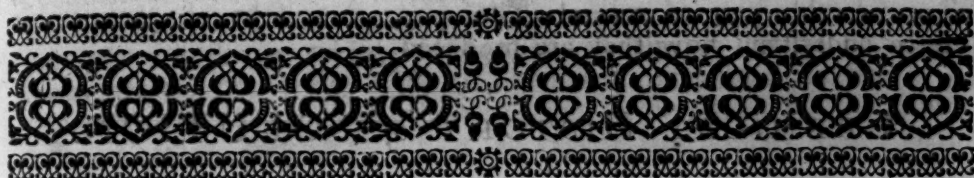
Processes upon Fossils.

taking; it likewise commonly cures quartans at the second or third: and this I have found true by repeated experiments. But when the fever proceeds from some internal disorder of the parts, as a schirrous or cancerous tumor, or the like; this medicine is of no efficacy at all. In other cases, it seldom fails above one time in six: and with this process we end the whole chain*.

* This chain of processes upon antimony deserves the utmost attention and regard of those who deal in mines, or desire to examine metalline ores. They present us, in effect, with the best methods of purifying metals, and bringing them to the test, or making essays thereof; and will, with the discerning chemist, pass for more than the diligent M. Lémery's laborious treatise wrote expressly upon the subject of antimony; for here, as in all the other parts of this noble work, our author

had a view to make his processes as universal as possible; that is, to make them serve for general examples in the chemical treatment of all the bodies of the same rank or class with that under consideration; whence this history of semi-metals, well understood, will instruct any one to treat fossils, or metalline ores, to as much advantage, as the chain of general processes perform'd upon animals or vegetables, will instruct him chemically to examine all the subjects of the animal or vegetable kingdom.





THE DOCTRINE

Of the preceding Chain of

PROCESSES,

Drawn out to exhibit the

Chemical History of the particular QUALITIES of
Natural Bodies.



WE have now methodically gone thro' that series of processes which seems to us sufficient fully to instruct anyone in the whole art of chemistry; for tho we have not directly exhibited the production of all that infinite number of medicines, or shewn all the chemical resolutions, compositions, &c. which have, and might still be for ever invented and discover'd by fresh combinations, and working upon all the various particular materials wherewith nature supplies us; yet have we laid the foundation for all such processes as are performable upon natural bodies; and shewn the general methods of performing them, according to the strict rules of art, by a variety of standard examples, which together make the elements of chemistry, or a regular system of general processes upon the productions of the vegetable, animal, and fossil kingdoms; which compleats the third and last part of our labour. Nothing remains farther to be done, but by way of corollary from this third part, to draw out the doctrine it contains, with regard to those remarkable

*Introduction to
the chemical
history of parti-
cular qualities.*

qualities, or phenomena of bodies, *Solution*, *Coagulation*, *Precipitation*, *Effervescence* or *Acid* and *Alkali*, *Odours*, *Tastes*, and *Colours*; which making a considerable part of natural philosophy, it will be of considerable use to understand how they are produced.

CHEMICAL HISTORY of SOLUTION.

*Solution, by
what means
effected.*

SOLUTION, according to all instances of it afforded us in the preceding series of processes, is performable, (1.) By *water*; which, as we have seen, dissolves bodies by dilution, maceration, infusion, coction, distillation, fermentation and putrefaction. (2.) By *oils*; which act only by dilution, infusion, coction, and distillation; and not, like water, by fermentation and putrefaction. (3.) By *fire*; which dissolves bodies by torrefaction, ignition, calcination, fusion and sublimation. (4.) By *inflammable* spirits; which act by dilution, infusion, coction, and distillation. (5.) By *fixed alkaline salts*; which act at the fire by torrefaction, ignition, calcination, and fusion; but together with water, or *per deliquium*, by dilution, maceration, infusion and coction; but not by distillation. (6.) By *volatile alkaline salts*; which, when used dry, act by sublimation; but when diluted, by maceration, digestion, coction, and distillation. (7.) By the more *fixed acid salts*, as oil of vitriol, &c. which act by dilution, digestion, decoction, and distillation. (8.) By *acid volatile salts*; which act by dilution, digestion, and distillation; but not by fermentation and putrefaction. (9.) By *compound and saponaceous salts*, whether acid or alkaline, fixed or volatile; which act according to their respective natures. (10.) Lastly, *Solution* is performed by metalline bodies; and that by means either of amalgamation with mercury, or fusion; for metals in fusion penetrate and dissolve one another. And these are the several means whereby the *Solution* of all bodies is effected.

CHEMICAL HISTORY of COAGULATION.

*Coagulation, by
what means
producible.*

COAGULATION, or the change of a liquid into a solid body, we have seen is performable by *water*; and (1.) upon *salts*, by turning them into crystals: for when any kind of salt, whether acid or alkaline, is dissolved in water, and the solution evaporated to a pellicle, it appears crystalline; the water rendring the salt transparent; and leaving it opake, as soon as by any means it is driven away. (2.) Upon *sulphur*; as in the golden sulphur of antimony. (3.) Upon *metals*, as in the vitriol of iron; to which it here gives transparency, as in the case of salts. (4.) Lastly, upon *earth*, whereto it gives a solid form; as in the making of tests, bricks, pots, &c. which would never hold together unless cemented with water. 2. Coagulation is also performable by *oils*, with salts, sulphur, and metals, the first whereof they turn into soaps, the second into balsams, and the third into plaisters. Thus ce-
ruse

ruse or minium, being boiled with oil, is thereby turned into a strongly coagulated matter, or solid mass. 3. Coagulation may be effected by *inflammable spirits*, with volatile, alkaline salts, as in the *Offa alba Helmontiana*; with the white of eggs, and serum of the blood, into a horny glebe; and lastly, with oil of vitriol, into solid sulphur or bitumen. 4. A fourth kind of coagulation is produced by the admixture of acids and alkalies; as in regenerated tartar, and *tartarum vitriolatum*, where the oil of tartar *per deliquium* is coagulated by oil of vitriol, and spirit of vinegar. 5. Fixed alkalies will likewise effect a coagulation; as milk, we saw, was coagulated by oil of tartar. 6. Acids also will do the same; thus the animal fluids are readily coagulated by oil of vitriol, &c. whence it is manifest, that coagulation is not the sole effect of acids or alkalies, as some have imagined. And besides these, there are other particular kinds of coagulation; as that of water, *sal mirabile Glauberi*, butter of antimony, &c.

CHEMICAL HISTORY of PRECIPITATION.

By *precipitation* we understand the recovery of any solid matter, dissolved into a liquid form, or its reduction to a solid again, by the addition of some other body. *Precipitation, what.*

This precipitation is effected, 1. By water, in all solutions of oil, and resinous bodies with alcohol. 2. By acids upon acids; as in the solution of metals. Thus a solution of silver in *Aqua fortis* will be precipitated by the affusion of spirit of salt, or oil of vitriol. And this shews the common opinion to be false, which supposes that acids can only be precipitated by alkalies. 3. A third kind of precipitation is of metals dissolved in acid menstrua by metals. Thus if a plate of copper be suspended in a solution of silver, made in *Aqua fortis*, and diluted with water, the copper attracting the acid stronger than the silver, which cannot enter the pores thereof; the silver adheres to the surface of the plate, in form of a blackish powder, which is afterwards precipitated to the bottom of the vessel: in the mean time the copper dissolves, and turns the menstruum blue. Now suspend a plate of iron therein, and this will be dissolved, and the copper precipitated as the silver was before; and by adding *lapis calaminaris*, the iron likewise may in its turn be precipitated, and so also may the calamine, by the addition of salt of tartar, which will thus be dissolved in its stead; all in proportion to the quantity of precipitate let fall. And this is the method, constantly practised by the refiners, of obtaining their metals pure out of the solutions they make thereof: and these phenomena have confirmed many in their opinion of the possibility of the transmutation of metals; the acid menstruum thus transforming or accommodating it self to all the kinds thereof. And there is a vitriolic mine in *Hungary*, where metals are in this manner naturally precipitated. *By what means effected.*

Whence

Whence we learn, that such precipitations may be effected without the mixture of acids and alkalies; tho alkaline solutions are indeed commonly precipitated by acids, and a solution of sea-salt or vitriol by oil of tartar *per deliquium*.

CHEMICAL HISTORY of EFFERVESCENCE; or the Doctrine of Alkali and Acid.

Effervescence,
what.

In what classes
of bodies it ob-
tains.

How producible
therein.

1. **E**FFERVESCENCE, in the chemical sense, signifies that violent intestine commotion which is immediately produced by mixing two bodies together, that lay at rest before. This commotion is usually attended with heat, frothing, a hissing noise, and a manifest ebullition; and is principally observed in fluids. To deliver the history of this phenomenon to advantage, we must consider it in four several classes of bodies; and lay down so many different rules with regard to the thing it self. The first class contains the manifest acids, as they are called, viz. vinegar, and its spirit, the juice of citrons, oranges, &c. spirit of nitre, spirit of alum, spirit of vitriol, spirit of sulphur *per campanam*, spirit of sea-salt, &c. The second contains the artificial alkalies obtained either from vegetables or animals, by distillation, putrefaction, elixation and calcination; as spirit of urine, spirit of harts-horn, salt of tartar, &c. The third class contains all those called terrestrial alkalies or absorbents; as the various kinds of shells, coral, chalk, bole, crabs-eyes, &c. And under the fourth and last come all the metals, and semi-metals; as gold, silver, lead, copper, tin, iron, quick-silver, antimony, zink, *lapis calaminaris*, &c. The effervescible bodies being thus distributed into classes, we come to give the rules which shew in what manner they may be made to exhibit their phenomena. And (1.) The subjects of the first class, being any of them mixed with those of the second, will always make a violent effervescence. (2.) In like manner, if any of those of the first class, are added to any of the third, they constantly exhibit the same phenomenon. (3.) Again, the subjects of the first and fourth class will also make an effervescence together: but this rule is not universal; for some of them will not constantly do it, tho others will. It is here remarkable, that coral, crabs-eyes, or other testaceous bodies, being put entire to any manifest acid liquors, as those of the first class, will, in the effervescence, be made to move or creep like living creatures; air, in the form of bubbles, continually breaking out from them. (4.) The objects of the third class differ widely from those of the second; and indeed agree with them but in one thing only; and that is in being effervescible with acids. The one is a class of fixed, scentless, insipid, mild, astringent fossil bodies; the other a set of such as are volatile, odorous, sapid, caustic, aperitive, and obtained by art.

2. Hence we may fairly conclude, that mere effervescence with acids ^{Use of the doctrine.} is not of it self sufficient to determine the nature of an alkali; and that such a name, which properly denotes a caustic, fiery substance, should not be affixed to any mild and gentle body, such as chalk, bole, coral, &c. only because it is effervescible with acids. The nature of acid and alkalies cannot, therefore, possibly be learnt by their effervescence, but requires a joint knowledge of their other properties also; as particularly their taste, manner of procuring, and the change of colour they produce in bodies*.

3. There are three very remarkable kinds of effervescence; viz. the ^{Three kinds of effervescence,} violently cold, the violently hot, and the fiery or suffocative.

If sal-ammoniac, or any pure volatile alkaline salt, be dissolved ^{viz. the cold,} in water, and mixed with the manifest acids, a violent ebullition, with a great degree of coldness, will ensue; so as immediately to make the thermometer sink considerably. This seems a paradox in philosophy, that coldness should be produced upon a violent agitation of the parts of bodies; the reason whereof is not well understood, tho the fact be certain†.

4. If to one part of *Glauber's* strong spirit of nitre, contained in a ^{The violently hot,} large glass vessel, there be gradually poured two parts of pure alcohol, prepared without the assistance of an alkali; a great effervescence will instantly be produced, with a considerable degree of heat. In which experiment, it is plain that the effervescence cannot be owing to any alkali, because there is none concerned. Nor can the like pretence be made as to the violent effervescence caused in the dissolution of iron by the same spirit of nitre; that metal containing a large proportion of sulphur, which abounds in acid, and affording no signs of an alkali.

5. The fiery, explosive, or ignivomous effervescence, is made by ^{And the fiery,} suddenly pouring one part of the essential oil of cloves to two of *Glauber's* spirit of nitre, made very strong and good; for at the very instant that they mix, a most prodigious effervescence, with a great eruption of flame and suffocating fume, ensues; as also an effect equal to that of gun-powder: so that it is very dangerous to make the experiment with any large quantity of ingredients, or otherwise than under a chimney; with great care to avoid admitting the noxious fumes at the nose, or receiving the sudden light with the open eyes. This experiment succeeds as well *in vacuo*, as in the free air; but never with alkaline salts. To make it satisfactorily, and without danger, the spirit of nitre

* The processes performed upon certain subjects of the animal kingdom, as a criterion of their acid, alkaline, or neutral nature, were therefore accommodated rather to the popular notion, than strict philosophical truth. But as all other experiments that can be made of the same nature, give their attestation, we may safely enough acquiesce in them: and of this particular notice was all along taken in the observations subjoined to each process.

† *M. Geoffroy* has some curious experiments, and a new system, relating to this subject, in the *Memoirs of the Royal Academy of Sciences*, for the year 1700. And *Mr. Boyle* furnishes us with numerous fundamental observations and experiments relating thereto.

may be a little weakened with water, and mixed with any of the other eleven oils mentioned, as fit for the purpose, in the philosophical transactions of *London*. And this grand effervescence shews a very destructive method of producing fire for the service of war. If a proper urn, charged with these two liquors, were to be thrown into a ship, or other retreat of the enemy, it might prove much more fatal than bombs and cannons. And a like effervescence might also be made with oil of vitriol and oil of turpentine; which shews us that the most violent fire, as well as effervescence, is producible by the joint action of oil and acid. And hence sulphur has its great inflammability; as consisting of an acid united to an oil. This also may serve to shew the reason of that strange effervescence observable upon mixing and grinding together the filings of iron and powdered sulphur, and afterwards reducing them to a paste with water; for if this paste be put into a close vessel, there will, in a short time, arise such a violent effervescence, as to burst the vessel with an incredible force, and black, suffocating fumes. And if a large quantity of such a mass of paste were to be buried deep under ground, it would soon cause a violent earth-quake, and burst out with a very great flame and stench. Which may serve, in some measure, to account for vulcano's, or the fiery eruptions of particular parts of the earth; tho it hitherto remains unexplained how such materials should thus spontaneously take fire.

CHEMICAL HISTORY of ODOURS.

*Odours, where
seated in vege-
tables.*

1. **V**EGETABLES we have found are resolvable into water, oil, salt, earth, and a presiding spirit residing in their oil: but neither water, salt, nor earth, when rendered pure, have any scent at all; tho they all become odorous if they contain any portion of oil, or the presiding or specific spirit. Thus the distilled waters of vegetables smell strong in proportion to the oil or spirit wherewith they are impregnated. The oil of vegetables therefore may, in the gross, be esteemed the chemical cause of their odour; or, to speak more accurately, the specific spirit residing in that oil; which may perhaps be a part of the oil it self, so subtilized and attenuated as to become miscible with water. Oil, therefore, in strictness, is not the cause of the odour of vegetables, any farther than that by being of an inviscating and tenacious nature, it serves to lodge and detain that subtile and impalpable substance, properly called spirit, which gives them their specific and distinguishing scent and virtues. For any, the most odoriferous oil, as that of cinnamon, if exposed to a gentle heat, presently loses its scent, without suffering any remarkable diminution of its weight. Hence it appears, that whatever cause can extricate the oil, or this subtile spirit, from vegetable bodies, will of consequence render them scentless.

How destroyed.

2. Animal

2. Animals also we have seen, are resolvable by chemistry into water, spirit, oil, salt, and earth; yet none of these, when pure, are possess'd of any odour, except the oil, or rather the subtil and invisible spirit lodg'd therein; which also may readily be set free by heat; upon which the oil loses both its specific scent and virtue. And therefore any cause able to extricate this subtil spirit from its prison, the viscid oil, will take away all the odour of animal substances. Where seated in animals.

3. Our preceding processes have likewise shewn us that fossil bodies are reducible into water, spirit, salt, sulphur, metal and earth; all which, so long as they remain at rest, even sulphur it self, yields no manner of smell; but when it comes to be burnt, whereby its parts are put into motion, it then proves strongly odorous. And thus even the metalline part of minerals assumes an odorous nature; as we have seen in the butter of antimony, which is a mere melted metal. In like manner sea-salt, which of it self has no scent at all, smells sufficiently strong when converted into spirit. Mercury also is perfectly inodorous, yet yields a strong scent when it comes to be dissolved in *Aqua fortis*. Hence it appears that all those causes which can bring minerals into action, or give motion to their parts, are capable of making them odorous; tho of themselves they are perfectly scentless. And according to their nature or specific characters, together with the nature of the operation they undergo, the scents they afford are varied. We observ'd a strong odour to be instantly produced from scentless bodies, when sal-ammoniac was mix'd with quick-lime. In the preparation of the golden sulphur of antimony, the scent of human dung was momentarily produced from bodies that before were partly inodorous, and partly of a grateful acid odour. A strong aromatic scent we also observ'd was caused by the mixture of pure alcohol, and spirit of nitre. And lastly, a violent odour we have found may be instantaneously destroy'd, by pouring spirit of nitre to any strong alkaline urinous spirit. In fossils.

CHEMICAL HISTORY of TASTES.

1. **T**HE perfectly pure water, oil, salt and earth, both of vegetables and animals, have no particular taste, any more than odour, sufficient to distinguish the principles of one subject from those of another. Tastes, whence in vegetable and animal substances. Salts and oils have the greatest pretence to it; yet the pure and perfect salt of liquerise cannot be known from the salt of wormwood: and if the operation be duly perform'd the case is universal. In like manner the strongest and most sapid vegetable or animal oil, by being expos'd to the free air, utterly loses all its taste as well as smell; and what remains thereof is not to be distinguish'd from oil of olives, oil of almonds, or any other pure and perfect oil. Whence we must conclude, that as oil alone conveys the specific taste of vegetable and animal substance, there must be some fine, sharp, subtil thing, or spirit residing therein, which when the

T r

oil

oil is once depriv'd of, the bodies lose their taste: and therefore whatever has the power thus to draw away this spirit from the oil, has the power of rendring bodies perfectly insipid.

Whence in softs.

2. As to minerals, all of them are destitute of taste, so long as they remain entire, and undissolved; but when once set afloat, they become vehemently sapid and pungent: whence it is easy to conclude, that tasteless bodies may, according to the nature of the solvent, acquire strong determinate and abominable tastes. Thus fix'd salts, distill'd from insipid sand, become violently acid spirits; as spirit of nitre, oil of vitriol, &c. Tasteless sulphur, by boiling in oil, becomes exceedingly nauseous upon the palate. The insipid body of silver, dissolved in spirit of nitre, proves most intolerably bitter upon the tongue; yet becomes insipid again when reduced from its vitriolic state to *luna cornea*. And by the like treatment the body of lead is made to taste sweet, as in the *Saccharum Saturni*. Whence we may see what numberless ways there are of diversifying, changing, and destroying the tastes of bodies *.

CHEMICAL HISTORY of COLOURS, exhibiting, in a series of Problems, the production, destruction, and changes thereof.

Variety of colours afforded by a black body.

WE learn'd from our processes upon antimony, that almost all kinds of colours are producible in that black solid body. Dissolved in *Aqua regia*, it affords a yellowish sulphur, and a white or greyish calx; which being sublimed with an equal quantity of sal-ammoniac, gives a very great variety of different hues; as we observ'd in obtaining the flowers thereof. And that in like manner colours may also be wonderfully produced and destroy'd in fluids, we shall shew in the following problems, with which we will close the whole.

* Mr. Boyle hath admirably treated these several subjects, in the chemical way, with a view to shew that all the particular qualities of bodies are mechanically producible; that is, by a bare alteration in the form or figure of their parts.

PROBLEM I.

1. To turn a pellucid liquor instantly black, by barely pouring it into a clean glass; or by the addition of a white, red, or a gold-colour'd substance.

2. Wash a glass in the clear solution of the vitriol of iron, made in fair water; and pour into it a slight and pellucid infusion of *Asiatic* galls, made also with water; and the liquor will immediately become black.

3. In the same manner, the transparent liquor or infusion of galls may be changed to a black, by throwing the smallest bit of a white or a red body into the glass; viz. a very little of the vitriol of iron, calcined to either a white or red.

4. To turn the transparent liquor black by a gold-colour'd substance, let fall a single drop of *Basil Valentine's* golden tincture of iron therein, and this will effect the change, tho scarce one thousandth part thereof be iron; which nevertheless is the whole thing that produces the change.

5. These experiments are order'd to be made with the artificial vitriol of iron; but the native may serve the turn: so likewise might the *Ens veneris*, which is prepar'd from native vitriol, reduced to colcothar, and sublimed with sal-ammoniac. For the effect would be nearly the same, except that the blackness produc'd would not be so full when the *Ens veneris* was employ'd; because the sal-ammoniac acting here as an alkali would somewhat hinder the striking of the colour.

6. Nor need the experiment be confin'd to the infusion of galls alone; sage, oak-leaves, pomegranate bark, or flowers, good green tea, red rose-leaves, &c. may be used instead thereof: a clear tincture or infusion of any of these turning black with a solution of vitriol, or other chalybeate liquors.

PROBLEM II.

1. To make a black liquor pellucid by barely pouring it into a clean glass.

2. Pour the black liquor already made, into a clear glass, wash'd with oil of vitriol; and it will presently become as clear and colourless as water.

3. The black liquor made from a solution of the vitriol of iron, will by this means become perfectly pellucid; but that prepar'd from colcothar, or vitriol calcined to redness, will only be brought to a yellowish colour, like

canary; on account of the predominant colour of the sulphur of the vitriol so high calcined. That made with *Valentine's* golden tincture of iron, will also remain inclining to yellow; and that with the *Ens veneris*, will afterwards turn something milky.

P R O B L E M III.

1. *To turn the foregoing transparent liquor black again.*

2. Pour into it a little oil of tartar made *per deliquium*, which will so mortify the acid that before took away the blackness, as to make it presently return again. But if the liquor should be made with *Ens veneris*, it will appear only of a purplish colour, tending to black.

P R O B L E M IV.

1. *To render this black liquor again pellucid.*

2. Pour more oil of vitriol to it.

P R O B L E M V.

1. *To change a pellucid liquor yellow, and milky, by pouring it into two clean glasses.*

2. Pour the clean solution of quick-silver in *Aqua fortis*, into two clean glasses, the one whereof has been rinsed with oil of tartar *per deliquium*, and the other with spirit of sal-ammoniac; and in the former the liquor will turn yellow, and the other milky.

3. This gives us a remarkable instance of a difference between a fix'd and volatile alkali.

P R O B L E M VI.

1. *To destroy the yellow and milky colours produced in the preceding problem.*

2. Drop spirit of nitre, or spirit of vitriol into them.

P R O

P R O B L E M VII.

1. *To turn a transparent red liquor milky, by barely pouring it into a clean glass.*
2. Pour the tincture of sulphur, prepar'd with fix'd alkali and alcohol, into a clean glass wash'd in some acid spirit, and it will immediately turn milky; as in the preparation of *Lac Sulphuris*.

P R O B L E M VIII.

1. *To change the white liquor of the preceding problem green.*
2. Drop into it a little oil of tartar, well diluted with water.

P R O B L E M IX.

1. *To turn a pellucid liquor of a beautiful violet-colour, upon pouring it into a clean glass.*
2. Pour a clear solution of copper made in spirit of vinegar, and well diluted with water, into a glass wash'd with spirit of sal-ammoniac, or spirit of urine.

P R O B L E M X.

1. *To destroy the violet-colour produced in the preceding liquor, by barely pouring it into a clean glass.*
2. Pour the liquor into a clean glass wash'd with oil of vitriol.

P R O B L E M XI.

1. *To change the liquor of the last problem, to a blue or sea-green.*
2. Drop into it a little oil of tartar *per deliquium*.

P R O

P R O B L E M XII.

1. *To make a rich beautiful green liquor pass thro various degrees of colours, into a fine sky-blue, or violet.*

2. Make a solution of copper with distill'd vinegar, which will be of a lovely green; and pour to it by degrees the spirit of sal-ammoniac, and it will pass thro various shades to a fine sky-blue, or violet.

P R O B L E M XIII.

1. *To reduce the blue liquor of the last problem back to a green again.*

2. Pour any strong acid, as oil of vitriol thereto, and it will pass thro' all the shades, till at length it ends in a green; from whence it may again be brought to a blue by the affusion of oil of tartar *per deliquium* *.

P R O B L E M XIV.

1. *To distinguish acids from alkalies, by the change of colour, they produce in the blue Syrup of violets.*

2. Those liquors which being poured to syrup of violets, change it of a fine red, or carmine colour, are accounted acid; and those alkaline which turn it of a kindly green. Thus oil of vitriol, or any the lightest acid, will instantly change the blue of that syrup to a red; as oil of tartar, or any the lighter alkali, turns it green. And this is accounted a sure criterion of acid and alkali. And if to this syrup, made red by the addition of oil of vitriol, oil of tartar be poured, it turns that part where-with it comes in contact green; but leaves all the other red. In like manner, if to a quantity of the syrup made green by oil of tartar, a sufficient or predominant proportion of oil of vitriol be added, it turns that part red which it touches, and leaves all the other part green. And so when larger quantities of acid and alkaline liquors are alternately mix'd

* This kind of problems might be varied *ad infinitum*. Whoever desires to see more experiments of this kind, and the doctrine they appear to establish, may consult Mr. Boyle upon Colours, and Sir Isaac Newton's Optics.

with the blue syrup of violets, they suddenly change it from red to green, and from green to red. And all this being consider'd, together with what we formerly observ'd as to the mixture of oils and water, which makes a white, and other particulars of the like nature, will lead us into a knowledge of the instantaneous production, change and destruction of *Colours*.



F I N I S.

The first of these is the fact that the
 second of these is the fact that the
 third of these is the fact that the
 fourth of these is the fact that the
 fifth of these is the fact that the
 sixth of these is the fact that the
 seventh of these is the fact that the
 eighth of these is the fact that the
 ninth of these is the fact that the
 tenth of these is the fact that the



INDEX

TO THE

New Method of Chemistry, &c.

N. B. *The Letter p. denotes the Practice, or third part of the Book; and n. the Notes.*

- A**
- Cetum Radicatum*, what. 355, 186, p
 - Uses and vertues thereof. 186, 187, p
 - Acids*, what. 338, 96, p. 98 p
 - Distinguished from Alcalies. 326, 327, 334, p
 - Good dissolvents, and whence. 353, 355
 - Their use how indicated. 98 p. 232 p
 - In fevers. 197
 - Are of three kinds. 353
 - Mineral, which. 353, 354
 - How they differ. 353
 - Dissolve the hardest bodies. 354
 - Changed in the operation. *ibid.*
 - Take up the mercurial part of metals. 353, 354, 293, p
 - Vegetable, which. 354
 - Lost by much drying. 96, p
 - Native, which, and their power in solution. 354, 355, 5
 - Of unfermented vegetables, how got. 355
 - Of fermented vegetables, which. *ib.*
 - The strongest acids rise latest in distillation. 149, p
 - May be loosely lodg'd in metals. 151 p
 - Determine alcalies. 249, p
 - Whether naturally contain'd in animal bodies. 338, 355, 356, n. 177, p
 - Assume a saline form with their solvents. 356
 - May make ebullitions, and be changed by acids. 319 p
 - See *alcalies and spirits.*
 - Acid*, a vague one, found in all parts of the earth. 112 & n. 136, n. 197, p. 254, p 301, p
 - How it forms various fossils. 301 p
 - Whether procurable from animals. 197, 198 p
 - Acid and Alkali*, the doctrine. 326--328, p
 - By whom well explain'd. 47
 - Assist each other in solutions. 351
 - Acidum Esuriens*, what. 123, 152, p
 - Action* in bodies, what. 323, p. 152
 - Adam* said to be an alchemist. 10
 - Additions* in working, the use. 49, 50, p
 - Ethiops mineral*, how made. 74, 297, p. 333
 - May be formed naturally. 295, p
 - Its properties and uses. *ib.*
 - Agricola (Foh.)* his book *de re metallica*. 40
 - A modern alchemist. 45
 - Agnes*, cure of. 40, 41, p. 85, p. 103, p. 109, p. 110, p. 163, p. 200, p. 204, p. 239, p
 - Air*, what. 277, n
 - Its effects on fire. 269, 270, 299
 - Whence necessary to fire and flame. 296, & n
 - Proper*, what. 277, n. 290, n
 - Its properties, structure, &c. 290, 291

A *Air*,

I N D E X

- Air*, how to produce it. 290.n
 Present in all chemical operations, and how it affects them. 219, 277, 287, 8. 303
 Found every where. 299
 Its fluidity, and motion owing to fire. 224, 225, 277, 288, 290, 291, 299
 Its office in respect of the rays of light. 239.n
 Its effects infinite. 290
 Not the pabulum of fire. 269, & n. 270, & n.
 Alter'd by the heavenly bodies. 278, 279, & n.
 Vital part, what and whence. 278, 296, n.
 Whence its effects arise. 281, 279.n
Common, a mixture of all sorts of bodies. 279, 280
 Tremors therein, whence. 279, 280
 Contains animal matters. 280 & n.
 All sorts of vegetables. 281
 All sorts of fossils. 281, & n. 288
 Divided into transient and permanent. 291 n
 Wholesome or unwholesome, whence. 281, & n.
 Exhalations therein of three kinds. 281, & n. 282
 Different in different places. 283, & n. 289 n
 seasons. 283, 288, & n.
 by cold, heat, &c. 284, & n. 304
 by thunder, earthquakes, &c. 284, n. 286.n
 Height or depth changes it. 286
 Changed by winds. 287
 by drought and moisture. 286, & n.
 Stains linnen. 286, n
 Its nature near towns. 287, n. 288, & n.
 How disposed in the blooming time of flowers. 288, & n.
 In fermenting, rusting, brewing, dying, &c. 288, & n. 289, & n. 302, n
 Generated by gunpowder. 290, n
 Its repelling force. 291 & n.
 Rarefaction. 291
 Specific gravity. 291
 If compressible in infinitum. 291
 Whether capable of the gravity of gold. 291
 Why more ponderous than vapour. 291 n
 Its gravity proved. 291, 292, & n.
 The uses thereof. 292
 Share in mixtures. 292, & n. 296
 Elasticity, its distinguishing property. 293
 Whence. 294 n. 295 n
 As its density. 297, 293 n. 294 n
 As powerful when confined as when free. 293
 Whether capable of infinite dilatation and compression. 294 & n.
 Infinitely porous. 294
 Condensed by cold, rarefied by heat. 294 & n.
 The rule of its dilatation. 294 n. 295 n
- May produce earthquakes. 287
 's Pressure, its force on the earth's surface. 294 n. 295 & n.
 Use to vegetables and animals. 295 & n.
 Its variation, how it may affect health. 29, 295 n
 Forwards the growth of salts. 297
 Has very odd properties, and whence. 296, 297, 8 n
 May cause thorough solutions. 298
 How kept from acting upon bodies. 298, 299
 Included, may burst the most solid matters. 299
 Causes putrefaction and fermentation. 299, & 300 n.
 In some countries how it affects certain colours. 300 n
 Qualities ascribed to it, owing to a more subtle medium. 296
 Can change the subjects of the vegetable kingdom into the animal. 300 & n. 301
 A solvent how. 301, 302
 Contains all sorts of menstruums. 301 & n. 302 & n.
 May have a peculiar corrosive or dissolving power. 301 n
 Its share in the actions of other menstruums. 302
 Fixes volatile, and volatilizes fixed bodies. 280, 302, 303 & n. 327
 Calls forth the latent powers of bodies. 303
 Contains active principles. 296
 Many of its effects not accountable for. 297, 298 n
 See *Atmosphere*.
Albertus Magnus, his character and writings. 15 & n.
Alchemists, to discover their impostures in making of gold and silver. 62, 67, 68, 80, 81
 Why not always successful. 44 n
 Their general principle. 296
 Their pretensions, besides the philosopher's stone. 217, 8
 Sum of their doctrine. 218
Alchemy, the word when and by whom introduced. 9
 Its technical meaning. 9, 10
 Antiquity of the art examined. 9, 10, 12, 13
 Wherein it consists. 42, 215
 Pretends to make gold, and find an universal medicine. 10, 42
 The best writers thereon. 42, 44, 45
 Three branches thereof. 42
 Its practice not expensive to the skilful. 42, 43
 Prohibited by Law.
 Accounted impious by some. 43 n
Palmarus condemn'd for writing on it. 42 n
Alcohol,

I N D E X.

- Alcohol*, what, and its two significations, p. 137, 138 p
 How procurable to advantage. *ib.*
 To examine its purity. 138 p
 Its properties, virtues, and uses. 138, 139 p
 Is a compound body. 140 p, 181
 Contains an oil. 140 p
 Not miscible with oil of tartar. 138 p
 Wets not saline bodies. 138 p
 Not easily changed. 138, 139, 141, p
 Its great volatility. 139 p
 Why mortal when too freely drank. 139 p
 Coagulates the animal fluids. *ib.*
Per se, how prepared. 137
 How prepared with fixed Alkali, and united therewith. 139, 140 p. 165 p.
 Nature, virtues, and uses. 140 p. 207 p
 Whether attainable in absolute purity. 140, 141 p
 When improper for tinctures. 59 p
 What it extracts from vegetables. 162 p. 166, 167 p
 Its affinity with oil. 170 p. 174 p
 May be used to adulterate the richer oils. 170 p
 Distill'd from oil of vitriol. 262 p
 Into what forms convertible. 165 p
 Whether into water or earth. 181, 298, 326 n
 Externally used may cause cancers. 207, 208 p
 Has no attenuating power in the body. 208 p
 Its embalming virtue. 213 p. 214 p
 Stops the growth of animals. 214 p
 Alter'd by salt of tartar. 181
 Whence its inflammability. 264
 The purest of all fuels. 267
 What bodies it dissolves. 352
 The same from all vegetables. 358
 Its use in dulcifying acid spirits. 358, 359
 Not easily changed by its solvents. 361, 362
 Becomes insipid by repeated distillations. 362
 See *Spirit of Wine*.
Alembic, what. 376, 56 p
 Whence the Name. 376
 Known to *Dioscorides*. 376
 Its structure and use. 376, 380
 To prevent its burning, and the head from flying off in working. 133 p
Aliment, its nature. 345
Alkahest, origin and derivation of the word. 363, 364
 How and where spoke of by *Paracelsus* and *Helmont*. *ib.*
 Origin of the thing. 366
 Its notion not irrational. 363
 Pretensions of several chemists to it. 363, 367
 Its effects in changing bodies. 308 n, 367, 368, &c.
 Its properties. 362, 367, 370
 Whether possessed by *Helmont*. 362
 Unknown to *Boyle*. 362, 363
 For what mistook by *Zwelfer*. 355, 151, 152 p
 Whether volatiliz'd salt of tartar. 364, 370
 What esteem'd by *Glauber*. 359, 364 & n. 337 P
 Conjectures as to its matter. 364, 370
 Words of like import therewith. 364, 366
 Differently spoke of by *Helmont*. 365, 366
 Is the product of art. 366, 367
Arbor Diana, requisite to its production. 314
 A greater arcanum than the philosopher's stone. 367
 Said to cure the leprosy. 367
 Changes all things but water. 367, 368
 In what order it changes bodies. *ib.*
 The criterions thereof. 367, 368, 369, 370
 Whence supposed a fiction. 314
 Its manner of application. 368
 Destroys not the seminal virtues of bodies. *ib.*
 Might produce a genuine aurum potable. *ib.*
 The bodies dissolved by it, raised in a sand-heat. *ib.*
 Leaves the solvent elementary water. 368, 369
 Apply'd to charcoal. 368, 369
 Not impaired in solutions. *ib.*
 But not absolutely incapable of change. 369
 Why call'd the immortal liquor. 369
 Is incapable of mixture. 369
 The manner of its action. *ib.*
 Various opinions concerning it. 367, 370, 371
 Not prepared from Urine. 370
 Not phosphorus. 366, 370
 What it probably was. 370, 371, 372
 Attempts to procure it. 371
 Whether the same with the sal circulatum of *Paracelsus*. 371, 372
Alkalies, what. 339
 Their exhibition how indicated. 98 p
 How prescribed to advantage. 232 p
 See *Spirits, Salts, and Acids*.
Alkali, fixed, what, and whence readily obtained. 339, 43, 44, 45 p. 236, 237 p
 The name whence, and how varied. 339, 45 p
 How it is known. 339
 How made to act as a menstruum. *ib.*
 How best purified. *ib.*
 Its use in preparing bodies for solution. 359
 How produced. 43, 44 p. 236, 237 p
 Attractive of moisture. 44, 45 p
 Changes colour in the fire. 44 p. 164 p
 Destructive of animal substances. 44 p
 A 2 *Alkali*,

I N D E X.

- Alkali, fixed*, its numerous properties. 45. 48
 Alterable by the salts of the air. 46. p. 55. p
 Recovers salts from their acid spirits. 46. p
 55. p
 Its corrosive power. 45. 46. p
 How made volatile. 46. p. 49. p
 Whether a production of art. 46. & n. p
 Its medicinal virtues and uses. 47. 48. p
 With what cautions to be administered. 47. p
 How run per deliquium. 48. 49. p
 Liquid how procured pure. 49. p
 Its gravity. 49. p
 See *Salts fixed*.
Alkaline disposition of the body, how known. 98. p
Alum, its kinds. 111. 112. & n
 Whether a proper salt. 112
 Where found. 112. n
 How made in *England*. 112. n
 Its stone. 112. n
 How made at *Civita Vecchia*. 112. n
 Its use in making spirit of nitre. 84
Rock-Alum, what. 112. n. 356
 How made at *Solfaterra*. 112. n
 How found in the earth. 112. & n. 113. & n
Amalgamation of metals, explained. 70
 The general method thereof. 296. 297. p
 Its use. 297. p
Amber, what. 127. & n. 128. & n
 Whether vegetable, animal, or fossil. 127. n
 128. n. 173. 174. & n. p
 Where found, and in what form. 127. n. 128. n
 Whether once fluid. 128. n
 Mix'd with foreign bodies. 128. n
 Its tastes and scents. 127. n
 Its Menstruum. 362. 161. p
 Its Tincture gained readily, and the virtues thereof. 161. p. 163. p
 How analysed. 161
 Its oil, salt, and spirits gained. 173. & n. p
 Its salt, how adulterated. 173. n. p
 Possibly a camphor. 174
 Virtues of its salt and oil derived from the air. 174. 179. 180. p
Ambergrease, what, and where found. 128. & n
 Its origin. 128. n
 Various opinions about it. 128. n
Ammon, the meaning of the word. 2
Analysis Chemical, productions thereof. 176.
 n. 187. & n
 In what manner conducted. 4. 7. p. 13. 14.
 p. 180. p.
 Its justness discoverable by recomposition. 14. 15. p
Anatomical Preparations, how preserved. 100. p
 103. 104. p. 135. p. 139. p. 163. 164. p
Anatrum, what. 109. n
Animals defined. 53. 163.
 Distinguished from vegetables and fossils. 163. & n.
 Not well defined from their motion. 164.
 & n. 165
 Have their atmospheres. 165. n
 Their solids, of what composed. 166. 167
 217. 218
 Unchangeable. 219. p
 Their fluids what, and whence derived. 167
 How distinguished chemically from those of
 vegetables. 168
 Coagulable by heat. 206. 207
 Yield no fixed alkali. 168. 169
 Contain no real acid. 168. & n. 169
 Their principles. 168. & n
 All their matters afford the same principles. 218. 219. p
 Have each a peculiar spirit. 168. 223. p
 Contain much water. 168. 169
 Contain a salt, and of what kind. 169
 Why no fix'd salt. 224
 Their Native Spirit lost in Chemical Operations. 218. p
 Contain an Oil. 169
 Considered as the subjects of chemistry. 169
 Into what resolvable. 187. & n. 188. n
 Naturally luminous. 239. n
Animals want the faculty of forming salts. 55
 p. 195. p
 Their salts, whence derived. 55. p. 197. 198. p
 How preserved by smoke. 96. p
 Are continually wasting and repairing. 179. p
 Their food, and how they are compos'd thereof. 179. 180. p
 May have some of their aliment and oil from the Air. 179. 180. p
 Their growth, how stop'd. 214. p
 Their bodies consist of vegetables. 180. p
 Their parts might once exist in milk. 180.
 181. p
 Naturally contain neither acid nor alkaline salts. 198. p. 208. p
Animal Matter, its growth like that of fossil. 166. n
 Wherein its virtues reside. 222. p
 How render'd unfit for nutriment by long coction. 219. 220. p
Animal Principles, how purified. 220. 221. p
Animal Spirits, whether existing in the body. 181. & n. p
 Whence they afford no fix'd salt. 224. p
Analing of Glass, what. 140. p
Anodyne, a fine one. 172. p
 In oil of turpentine. 103. p
Antimonium diaphoreticum nitratum, how made. 311. p
 Its virtues, uses, &c. 311. p
 Dulce, how made. 311. 312. p
 Its ill effects on the body. 312. 313. p
 Helmontij, how made, &c. 321. p
 Antimony.

I N D E X.

- Antimony*, its chemical character explained. 56. 58. 132
 Its various names in chemistry. 66, 67. 85
 132, 302. p
 What, and where found. 302. p
 How purified for use. 302. p
 How to be chose. 302. p
 Male and female what. 302. p
 Its nature. 58. 85. 351. 303, 304. 306. p
 Its use in cupellation. 66, 67. 85
 Volatilizes all metals but gold. 85
 The last test of gold. 67
 Emetic virtue of its glass. 117
 A medium between gold and silver. 131.
 Divided into a metalline and sulphurous part.
 303, 304. p
 The nature of its sulphur. 303, 304. p
 To purge it of its sulphur a desideratum.
 131, 303. p. 304. p. 306. p. 308
 Attempts to render it a metal. 131. 308. p
 Whereof it consists. 132
 Whether capable of resolving gold. 132
 Where and in what forms found. 132. n
 Of two kinds. 132. n
 The common, what. 132. n
 Gains weight in calcination. 251. 252
 Its power in dissolving metals. 334
 Whether it destroys their nature. 334
 Its genuine mercury, how procurable. 333. n
 Its tincture, how made. 351
 Its virtues, whence. 302. p
 How dissolved in aqua regia. 303. p
 Converted to a very corrosive powder. 303. p
 How purified by bare fusion. 304. p
 How purified with flux powders, or reduced
 to a regulus. 305, 306. p
 Its golden sulphur, how procured. 308, 309. p
 Virtues and uses thereof. 309. p
 Its crocus or liver, how prepared. 309. p
 A mild emetic, how made from it, and how
 used, &c. 310. p 317 p
 Its vomitive poison corrected by nitre. 312. p
 Its diaphoretic nitre. 313. p
 Its fixed sulphur, how obtained, with the
 nature thereof. 314. p
 Its milk, what, with the virtues thereof. 314. p
 Its butter, or icy oil, what and how made.
 314. p 30. p 316. p
 Poisonous nature thereof. 316. p
 Its conversion into oil, with the uses thereof.
 316, 317. p
 Its conversion into mercurius vitæ. 317. p
 Its purple tincture, how made. 317. p
 Its emetic flowers, how prepared, with their
 virtues. 320. p
 Variety of colours producible therein. 320. p
 Its fixed flowers, how made. 321. p
Helmont's purging flowers thereof, and their
 virtues. 321. 322. p
- Ants*, whether they yield an acid spirit by di-
 stillation. 355
Apoplectic Balsams, how prepared. 110, 111, 112. p
 How to colour them differently. 111
 Their uses and virtues. 111. p 112 p
Apozems, what. 21. 23. p
 Wherein they differ from infusions. 23. p
 How made to the best advantage. 21. 23. p
 See *Decoction*.
Aqua adeptorum, what. 76
Aqua fortis, what. 65. 84. 240. p
 How made. 84. 241
 Its use in separating gold and silver. 71. 85
 To try its purity and proof. 84. 280. p
 The metals it dissolves. 354
Aqua divina Fernelii, what. 209. p
Aqua immortalis, what. 76
Aqua Philosophorum, what. 76
Aqua Regia, whence its name. 65
 What and how prepared. 65. 84. 246. p.
 250. n. p.
 Its use in separating gold. 71
 What bodies it dissolves. 354
 How made to dissolve silver. 84. n
Arcanum Corallinum, what. 291. p.
Archæus, *Helmont's* notion thereof. 33. 34
Arnoldus de Villa Nova, his history, writings,
 and doctrine. 19; 20. & n
Aromatics, wherein their virtues reside. 168. p
Arsenic, its poisonous nature. 126. 127
 Work'd for gold or the philosopher's stone.
 11. 126
 Supposed capable of fixing mercury. 127. n
 How obtained from *Cobalts*. 134. n.
 White and red. 126. & n
 Crystalline, whence obtained. 126. & n
 The common, which. 126. & n
 Makes metals brittle. 126
 A peculiar menstruum for it wanted. 126
 Changes copper like silver. 126
 Insoluble in water. 127. & n
 Greatly alters metals. 126, 127
 Dangerous to handle. 127. n
Art, what. 52
Artephius, an author in alchemy. 45
Ascites, how formed. 212. p
Asbes, what. 271. 29. 30. p
 How made consistent and hard. 330
 How gained insipid from Vegetables. 29. 30. p
 How gained saline from vegetables. 32, 33 p
 Retain the figure of the plant. 29. p. 32, 33. p
 What they contain. 29. p. 32, 33. p
 Of all vegetables virrifiable. 45. p
 Those of distill'd and fermented vegetables.
 64. p
Asphaltum, what. 127
 How sophisticated. 127. n
 The antient or supposed mortar of the walls
 of *Babylon*. 127
As-

I N D E X

- Asphaltum*, where found. 128
 Whether a solid or a liquid sulphur. 128
Asthma, a remedy for it. 173. p
Athanasior, what. 378
 Its structure and use. 378, 379
Atmosphere, effects of light or fire thereon. 278.
 & n. 279. & n
 A chaos of all things. 279. & n. 280. & n
 & c. 301, 304.
 The exhalations therein. 279. 290
 Consider'd as a chemical vessel. 281
 Why a moist one lighter than a dry. 291. n
 Its weight, whence. 294. n. 295. n. 310
 See *Air*.
Atoms what, and their hardness. 173. n. 343
Attraction, its notion explained. 171. n
 Its species. 171. n. 172. n
 How far known. 172. n
Attrition, what. 249
 How and in what proportion it collects fire. 249
Averni, what. 281
Auripigmentum, what and where found. 126 & n
Aurum fulminans, how made. 298. n. p
Aurum Philosophorum, what. 68
 Its great simplicity. *ibid*.
Aurum potable, what, and how made. 72. n
 317. p. 268
 From vitriol. 236
 Made by bare motion. 335. & n. 336
 A genuine one. 335. n
 Procured from all metals ground with water. 336
 Craftily counterfeited. 352, 353
 Easily procurable by means of the *Alkalest*. 368
 A sham one, how made. 256. p
Azure, what, and how prepared. 137. & n
- B.
- B** *Acon* (Roger) his history, character of his
 writings, chemical doctrine and ex-
 periments. 15. 17
 Condemned for a magician. 17. 211
 Acquainted with gun-powder, phosphorus
 and the air-pump. 17. 210, 211
Balm, what. 159. & n
 Its kinds, of *Gilead* described. 159. n
 See *Balsam*.
Balneum, *Arenæ*, what. 324
Mariæ, what. 324. 380
Roris, what. 324
Vaporis, what. 324
Ventris equini. 324
Balsam, what. 159. p
 Its kinds. 159. n
 Of *Peru*, its kinds. 159. n
Capivi its kinds. 159
- Whence. 93. p
 Whence the name. 112
 All contain an acid volatile salt. 105. p
 How changed into oils. 105. p
 How changed into refin. 105. p
 How affected by the Sun's heat. 105. p
 Why the most plentifully found in ever-
 greens. 105. p
 Dry, how analysed. 105, 106. p
 Some totally volatile. 105, 106. p
 Of sulphur, how made. 258. 262. p
 Of metals, what. 258. p
Balsamum sulphuris commune. 258. p
Terebinthinatum. 258, 259. p
Anisatum. 259. p
Barchanufen, (*Joh. Conr.*) his writings charac-
 teriz'd. 39
Bark of vegetables, what. 158
 Its offices and uses. 158, 159
 Various juices thereof. 59, & n. 160. & n
Barley, wherein it differs from malt. 125. p
Barometer, why it sinks upon winds. 287
 Whence in continual vibration. 289
 Why uncertain at great heights. 244
Baths Chemical, their origin. 275. 324
 Their different degrees of heat. 324
Baulm, its water. 64. p
 Virtue of its oil. 84. p
Beer, what. 214
 Whether a wholesome drink. 214. n
 How made. 214. n
Bees, how they gather wax and honey. 153,
 154, 155. n
Beguinus (*Johannes*) his *Tyrocinium Chemicum*,
 recommended. 38
Bell-metal, of what composed. 98. & n
Benzoin, virtues and uses of its tincture. 158. p
Bezoar Mineral, how prepared. 318. p
 Its nature. 318. p
 By whom first introduced. 318. p
Bile, whence it may cause great disorders in
 the body. 72. p
Birch, virtues of its sap. 118, 119. p
Bismuth, what. 133. & n.
 Where found. 133. & n
 Artificial, how made. 133. & n
Bites venomous, how cured. 213. p
Bistern, what. 108. n
Bitumen, how form'd in the earth. 113. n. 127
 What. 127.
 Its kinds. 127. & n
 Class'd. 127. & n
 Form'd by art. 129. & n. 130. n
Bitumen Judaicum, what. 127
Black bodies, why soonest heated. 243. & n. 244
Bleeding of trees, how practicable to advantage.
 151. n. 152. n
Block-tin, what. 96, 97. n
Blood, what. 167
 The

I N D E X.

- Blood*, the parts procured from it. 167
 To preserve it from putrefaction. 322
 How distill'd with safety. 330
 Whether it contain any acid. 355, 356. & n
 How resolved when coagulated. 214, 212. p
 That of pleuritic persons, how reducible to its natural state. 212. p
 How preservable uncorrupted. 213. p
 Its spirit, how gained. 215. p
 A knowledge of its phenomena upon mixture, necessary. 229. p
 Its phenomena upon mixing with salts and oils. 230. 232. p
 How it separates spontaneously. 230. p
 Its specific gravity variable. 230. p
 How impaired. 232. p
 Coagulated by acids, but liquified by alkalies. 331, 332. p
 By what things thickned, and by what thinned. 232. p
 See *Serum*.
Blood-Hounds, whence they distinguish odours. 168
Body, defin'd. 52. 250
 Sensible and insensible. 52, 53
 Divided into three classes or kingdoms. 53
 A simple body, what. 67
 Indifferent to motion or rest. 192. & n
 Its action, whence. 192. & n
 Its composition. 343, 62 n. 173. n. 330. n
 Either fixed or volatile. 63
 Whence indestructible and unalterable. 173
 & n. 174. & n. 329
Bodies, into what generally resolvable by chemistry. 187. & n. 173, 174. p
 Some not resolvable by fire. 179. n
 How preserved from corruption. 300. 103, 104. p. 138, 139. p. 146. p. 163, 164. p. 171. p. 176. p. 201. p. 207. p. 213. p.
 How analysed to discover their kingdom. 173. p
 Whence their difference. 223. p
 Human body not destroyed by the fierce circulation of the blood, &c. 23. p
Bohnus, his writings characteriz'd. 47
Boiling, how liquors are affected therein, as to degree of heat. 272. & n
Boles, what. 132
 Their use in distillations. 240. p
Bollito, what. 140. n
Bolt-head, what. 375
 Its use. 375
Bones, how reducible to earth, and again recoverable. 167
 How formed from milk. 184. p
 Yield no fix'd alkali. 217. p. 219. p
 Abound in water. 217. p
 Afford a copious volatile salt. 217, 218. p.
 Their composition. 219. p
 Yield not the animal principles after long lying exposed. 219. p
Bone-black, what and how made, with its uses. 218. p
Borax, what kind of salt. 111
 Native and artificial. 111. n
 The artificial, how made. 111. n
 Its history imperfect. 111
 Pliny's account thereof. 111. n
 Where found. *ibid.*
 The factitious, only the native purified. *ibid.*
 Its properties. 111
 Its uses. *ibid.*
 Why called *Chrysocolle*. *ibid.*
Boyle (Robert) his character. 46
 His writings characteriz'd. 46, 47
 Cleared from the imputation of credulity. 47
 His profuse encomium of certain remedies, whence. 47
Brandy, what and how made. 132, 133. p
 Whence its yellow colour. 134. p
Brass, what, and how made. 88. n. 133
 Turn'd to gold. 46. n
 How practicable to advantage. 151. n
Brewing, its origin and inventor. 214
 Directed by chemistry. 214, 215
 The process of it. 214. n
 How practised on corn, pulse and nuts. 126, 127. p
Bricks, whence their red colour. 93, 94, 267. p
 How made. 316
 How managed in the kiln. 267. p
Brimstone, how made. 252. p
 See *Sulphur*.
Burning, how effected. 230. n
Burning-glass, its effects on gold and silver. 64. & n
 Its manner of acting. 226. 241
 Its action upon metals explained. 100. n. 101. n
 231. & n.
 Most forcible in winter. 231
 To augment its force. *ibid.*
 Made of different matters. 257, 258
 Of ice. 285
Burns, how cured. 180. n
 Curable by fire. 213. p
Butler's stone, its effects seen by *Helmont*. 34, 35
 Of what composed. 89
 C.
Admia, what. 133. & n
Calamine, what and how prepared. 133. & n
 Its uses. 133. n
 Adds something metalline to copper. 133
 Cal-

I N D E X.

- Calcanthum rubefactum*, what. 299. & n. p
Calcination, what. 175
 Never effected without air. 303
 Whence it whitens bodies. 31. p
 By moisture, what. 264. p
Calx, of a metal, how reducible to a metalline form. 64. 72. n. 79
 Of lead, how recoverable. 79
 Increased in weight by further calcination. 79
 What species of body. 122. n
Camels, how form'd for travelling. 199
Camera obscura, how made. 253
Camomile flowers, virtues of their water. 64. p
 Virtues of their oil. 85. p
Camphire, what and how form'd. 86. p. 171. p
Cancers, how cured. 247. p
Cantharides, effects of their tincture in alcohol. 168. p
Caries of the bones, whence. 196
 How cured. 196
Casks, old, why prefer'd to new. 121, 122. p
Cataplasms, not to be applied hot. 207. p
Cathartics, what, and how they act. 39. p
 Deprived of their force by acids. 166. p
Cathartic potions, what, and how made. 164. p
 Their excellence and manner of use. 164. p
 How to diminish their force. 166. p
 Wherein their virtue resides. 166, 167. p
Catoptrics, what. 243
Cautic, common, how prepared. 50. p
 Whence its force. 51. p
 Attracts moisture. 51. p
 Its uses. 51. p
Cement, what. 335. p
Cementation. 334. 335
Cements, of what composed. 335
 Their manner of action. 335
 For mending cracked glasses, and *China-wave*. 382. & n
Centivoglio, his history and writings. 45. 81
Ceruse, what, how made and used 79. 272, 273. p
 Its poisonous quality. 273. p
Chalk, what and whether a stone or earth. 123. n
 How dissolved in water. 342, 343
Chalybs cum sulphure, how made. 272. p
Characters, in chemistry, their origin and rationale. 56. 58
Charcoal, what, &c. 29, 30. p. 38. p. 264
 How made. 265, 266. 29. 30. p
 Which the best. 266
 Its poisonous quality. 266
 Will long sustain the fire, if the air be excluded. 303. 38. p. 42. p. 96. p
 Transmuted by the alkahest. 368
Cheese, what, and how made. 183, 184. 75
 Why sometimes rank. 75
Chemistry, orthography, origin, &c. of its name. 1. 2
 Origin of the art. 2. 3
 Reveal'd by *Demons*. 2, 3, 4. n
 Its fabulous origin. 4. n
 Why not treated of by *Latin* authors. 4
 Why reputed a sacred art. 5
 Lost and revived. 16.
 Definition of the art. 51. 174
 Division of the art. 5. 9. 13
 Metallurgia the most ancient part. 5
 First practis'd by *Tubal Cain* in *Egypt*. 16.
 Its different appellations. 8, 9
 The authors therein, with their characters, &c. 14. 36. 37. 50
 By whom applied to medicine. 22. 30, 31. 199. n
 Dangeroufness of its practice. 37
 Best authors in chemistry selected and classified. 38. 50
 Systematical writers. 38. 40
 Writers on metallurgia. 40. 42
 On alchemy. 42. 46
 On the physical and medicinal part. 46. 50
 Its object, what. 52. 53
 Its effects produced by motion. 170. 180
 & n. 173
 Hints towards a rational account thereof. 171. n. 172
 Its difference from mechanics. 173
 Its operations whereon depending. 173. n
 Reducible to two kinds. 174. 18. 347
 Its productions. 189. 190
 Its end, and uses. 191. 218
 Wholly experimental. 192, 193
 Coincides with natural philosophy. 192, 193. & n
 How to be applied. 193
 Supposes mechanics. 193
 Accounts for the composition of animal solids, and cohesion of fluids. 194, 195
 Its use in pathology. 195
 in semeiotics. 196, 197
 in hygiene. 197
 in therapeuticks. 197
 in chirurgery. 198
 Censured by the faculty of *Paris*. 198, 199. n
 Its use in painting. 200. & n. 201. & n
 in staining glass. 201. & n. 202. n
 in enamelling. 202. & n
 in dying. 203, 204
 The art of Glass. 204. & n. 205. & n
 of Gems. 205, 206
 of fossils or mines. 208
 of metals. 208, 209
 of war. 209, 211
 of fire-works. 210, 211
 of natural magic. 211
 in working sham miracles. 211, 213
 in cookery. 213
 making wines and other drinks. 213, 214
Che-

I N D E X.

- Chemistry*, its use in brewing. 214, 215
in alchemy. 215, 218
Its instruments, what. 218. & n
Its ultimate effect in resolving bodies. 347
A course of operations therein, how to be
conducted. 4. p. 7. p. 8. p. 12. p. 180, 181. p
Limitations of the art. 16, 17. p
Chemists, adopt the hieroglyphic way of writ-
ting. 56
Chirurgery, how improved by chemistry. 198
Cholera morbus, a remedy for it. 64. p
Chrysopæan art. 9. 11
Chyle, what, and its origin. 74, 75. 161. 167
180, 181, 182. p
How made blood. 167, 186, 187. p
Whether vegetable or animal. 180, 181, 182. p
White, and how turned red. 184, 185. p
How prepared in the body. 74. p
Its difference from milk. 75. p
Its office and use. 216. p
Whence apt to turn acid. 75. p
Cinnabar, native, what, and where found. 76,
77. 132. & n
The marcasite of quicksilver, and reducible
thereto. 132. n
The facitious, what, and how prepared.
132. n. 133, 134, 296. p
The manner of working it. 134. n
Its virtues and uses. 296. p
Of antimony, how prepared, &c. 219. p
Cinnamon, its proportion of essential oil. 81. p
Virtues of its oil. 81, 82. p. 84. p. 89. p
Its oil turned to salt. 82. p
How sophisticated. 88, 89. p
Circulatory Vessel, what. 375
The manner of its use. 376
Citron-peel water. 64. p
Virtue of its oil. 84. p
Clarification, the several ways of effecting it.
26, 27. p
Clays, whether simple earths. 123. & n
Classed. 123. & n
Porcelain a clay. 123. n
Imitated. 123. n
Its specific gravity. 123. n
Clouds, acting as burning glasses. 245
Their figures. 245
What they contain. 246
Their height. 285. & n
Cloves, *Indian*, sophisticated, before importa-
tion. 87. p
Virtues of their oil. 87. p
Clyffus, what. 190
Coagulation, how and by what means produced.
324, 325. p
Coal, what, and whence combustible. 263
38. p. 30
Its blackness, whence. 263
Its different kinds. 265, 268
Pit-coal, what, and how to be chosen. 267
How clear'd. 267
Coal, Animal, what. 218. p
Coating of Retorts, what and how perform'd.
382, 383
Cobalt, what, and where found. 133. & n. 134. n
Whereof compos'd. 133. n
Yields no poisonous fumes. 133, 134
Cochineal, grain, what. 203. n. 204. n
How made to dye scarlet. 203
Whether an animal, or a vegetable matter.
203. n. 204. n
Cocœa-nut, how far reducible to oil. 22. p
Coction, its effect on vegetables. 22, 23. p
Cohesion, its cause. 62. n
Its requisite. 343
Cohobating, what. 16. p. 57. p. 61. p. 63. p
Of distilled waters, how perform'd. 61. p
Its use. 61. p. 64, 65. p
In what subjects performable to best advan-
tage. 62. p
Colcothar, what, and how procur'd. 135. n
266. p. 299. & n. p
Reducible to iron. 266. p
Its virtues and uses. 267. p
Cold, what. 224, 225. n. 235
In different bodies, as their weights. 74, 75
Whence different in different places. 235
Far exceeding that of ice. 240, 248
When greatest. 244, 248
Effects thereof on the mountains of *Peru*, &c.
244
No absolute cold. 248
Producible from warm bodies. 260. n. 261. n
Experiments about it by mixtures. 261. n
Its ill effects, how prevented in the body,
103. p
Colic, remedies for it. 242. 109. p
Colophony, what, and how procur'd. 160. n
92. p. 101, 102. p
Wherein it differs from *Resin*. 101, 104. p
Its use in preserving insects, &c. 104. p
Its medicinal virtues. 104. p
Calouring, of glass and precious stones, by whom
invented. 20
Colours of bodies, what and whereon depending.
173. n. 228, 229. n. 242, 186. p. 187. p
Pleasingly varied in the same subject. 93
Variously producible in a black body. 320
p. 330. p
The chemical doctrine thereof. 330, 335. p
Their nature, production, changes, &c. 330,
335. p
How alterable by mixture. 330, 335. p
For painting, afforded by chemistry. 200
Depend on fire. 228, 229. & n. 230
Comets, use of their tails. 278. p
Contusions on the Tibia, how cured. 104. p
Convulsions, how treated by *Sydenham*. 198
Cookery, depends on chemistry. 197. 213
B
C

I N D E X

- Copper*, its nature. 57
 Its chemical character explained. 57
 Its specific gravity. 59. 88
 Ductility. 88
 Extreme divisibility. 88. n
 Colour, and how changed. 88 & n
 Fixedness. 88, 89
 Difficulty and danger of its fusion. 5. 6. 88. 90
 Easily dissoluble, by every salt, oils, &c. 88, 89 n. 287. p
 Different colours of its solutions. 89. 187. p
 Its rust, what. 88, 89
 Why called *Venus*, &c. 89. & n. 287. p
 Volatilized by lead and antimony. 89
 Its elasticity and sound. 89
 Varies its colour with the solvent. 89
 Its calx, what. 89
 Why used for trumpets. 89
 Emits poisonous fumes. 89
 Its uses and medicinal virtues, what and whence. 89. 90. 151. p
 The basis of the most famous remedies. 89
 A quick emetic. 89
 Where found, and in what forms, 90. & n
 Whence its high price. 90
 Hard to purify. 90
 Blanched with arsenic. 126. n
 Whether dissoluble by oil. 351, 352
 Its tincture, what. 150, 151. p
 How dissolved and crystallized with vinegar, and sal armoniac. 285, 286. p. 287. p
 Virtues of such solution in spirit of sal armoniac. 287. p
 See Verdigrise.
Copperas, what, and how made. 135. n
Coral, a vegetable. 143. & n
 Its origin and semen. 143. & n
 Its flowers, seed, &c. 143. & n
 Its analysis. 143. & n
 Of various colours. 143. & n
 Its menstruum. 349
Coral red, its tincture, how procurable. 360
Corn, how malted, universally. 123, 124. p
Corrosion, a relative word. 360
Corruption, unintelligible without chemistry. 195
 What. 195
Cosmetics, the innocent, which. 48. p. 158. & n. p. 174. p. 289. 290. p
 The dangerous, which. 158. n. p. 273. p. 275, 276. p
Coughness, a good medicine therein. 40, 41. p
 How remedied externally. 106. p
Cream of Tartar, what. 154. p
Creation, how conceived of by *Paracelsus* and *Helmont*. 366, 367
Crisis, by urine, mechanically explained. 189.
 190. p
Crocus Martis, what. 93
 Its virtues and uses. 272. p
Astringens, how prepared. 266. p
Aperients, with sulphur. 272
Crocus metallorum, how made. 309, 310. p
 Its virtues and uses. 309, 310. p
 To abate its emetic force. 309
 Losses of its virtue, by repeated infusion. 310. p
Crollius (*Oswaldus*) his *Basilica Chymia*, characterized. 38
Crystal, described. 115
 How stained to imitate gems. 116. 205
 The manner of its formation explained. 120, 121
 Found in a red earth. 123. & n
 How disposed for making Gems. 205
Crystal-glass, how made. 139, 140. n
 How disposed for making Gems. 205
Crystal, Island, how it affects the rays of light. 255. & n. 256. n
 Of metals, whence their transparency. 267
Crystallization, explained, 120
 Its cause. 321
 How hindered. 397. p
 Its separating property. 235, 246. p
 How effected in metals. 264. p
Cucurbit, what. 375
 Its use. 375
Cuogolo, what. 139. n
Cupels, what, and how made. 167. 326, 327. 318. p
 Their properties. 326. 218. p
Cupellation, explained. 66, 67
 Its rationale, and manner of acting with lead. 80, 81
 How it separates gold and silver. 81
Curmi, what. 214. n
Curse, what, according to *Paracelsus*. 153. p
- ## D.
- D***emons*, antient and modern doctrine thereof. 2, 3, 4. n
Darkness, light plentifully contained therein. 227. 239
Dead-bodies, to preserve. 76
 Why cold in hot climates. 240
Decoctions, what, and how made. 20, 21. p
 What parts of vegetables they contain. 21, 23
 To make them rich. 21, 22. p
 Into what reducible. 22. p
 Wherein they differ from infusions and extracts. 23. p. 27. p
 How made to best advantage. 23. p. 24. p. 25. p
 Vegetable subjects best fitted for them. 24, 25. p
 How administered. 24, 25. p
 Carry the virtues of simples into the blood. 25. p
 How clarified. 26, 27. p
Dee, his history. 45, 46. n
 Dee,

I N D E X

- See*, whether possess'd of the philosophers stone, 45, 46. n
- Defrusta*, what, and how made. 25, 26. p
- What the word antiently signified. 25. & n.
- Nature and uses thereof. 27, 28. p
- Delivery*, to promote. 87. p
- Dentifrice*, an innocent one. 30. p
- Deobstruents*, what, and how they act. 39. p
- Desiderata*, in chemistry, to convert the glass of lead into lead. 80
- A vessel to hold the glass of lead in fusion. 80.
- A matter which cupelled with lead will fulminate therewith. 80
- A more perfect acquaintance with lead. 81
- To clear silver of its adhering sulphur, without loss. 86
- To facilitate the separation of copper from its ore. 90
- To purge tin of its sulphur. 96. 133
- To fuse crystal. 116
- A powerful attractive or dissolvent of sulphur or arsenic. 113. 126. 131
- To purge antimony of its sulphur. 131
- An innocent solvent for the stone in the bladder. 341. 349. 352. 357. 361
- A new set of menstrua by composition. 358
- To fix the colour of verdigrease. 286, 287. p
- Diamond*, why the chief of gems. 115
- Of what composed. 115. 317
- Its specific gravity. 115
- How known for genuine. 115
- Attractive. 117
- Its electricity, how increased. 117
- Made lucid. 117. 232. n
- Its grain. 119
- A visible motion in its parts. 223
- Digesting furnaces*, how made. 379
- Their uses. 379
- Digestion animal*, whereon it depends. 117. 117. p
- Chemical, its notion explained. 174, 175.
- Digestor*, *Papin's*, its manner of acting. 292, 293
- Dioptries*, what. 243
- Diseases*, whence produced; and when from acid, and when from alkaline causes. 185, 186. p. 189. p. 212. p
- How judged of from milk, urine, &c. 184. p
- Whence mortal. 189. p
- Chronical, whence. 39, 40
- Of women, remedies for them. 89. p
- How they may arise from a bare stagnation of the fluids. 194, 195. p. 209, 210, 211, 212. p
- Inflammatory, how to be treated. 212. p
- New ones, whence. 282
- Distillation*, what and how perform'd. 374
- How to order the vessels concern'd therein. 374-375. 58. p
- Subjects best fitted for it. 59. p
- How and when to be gathered, and how prepared. 59. p. 62. p
- What subjects are unfit for it. 62. p. 64. p
- How performed upon fermented vegetables. 65, 66. p
- Effects of its being continued therein. 134. p
- Per descensum, the manner of it. 68. p
- Of inflammable spirits. 132. p. 141. p
- What parts of vegetables ascend therein. 56. p
- Destroys not the fix'd salt of the subject. 134. p
- Mischiefs arising from it by ill management. 58. n
- How practicable with safety in preparing phosphorus, &c. 330
- The physical knowledge it affords. 59, 60. p
- How to be applied and regulated universally. 60. p. 62. p
- Distilled waters*, impregnated with the metal-line parts of the Still, noxious. 58. p
- To remedy such ill effects. 60. p
- Wherein their virtues reside. 59. p
- Their difference at different times of their running. 60. p
- Their virtues. 60. p. 63, 64. p
- Diuretics*, what, and how they act. 39. p
- Doronicum*, affording quicksilver. 76. n
- Dropsy*, how cured by copper. 89
- How treated by *Sydenham*. 40. p
- by *Harvey*. 162
- Whence its symptoms, and how mortal. 194, p. 195
- Medicines for it. 287. p
- A powerful cathartic for it. 282. p
- Drunkennes*, what. 130, 131. p. 139. p
- Its difference from stupefaction. 130, 131. p
- Its effects. 130, 131. p
- How remedied and prevented. 146, 147. p
- Allied to the apoplexy. 139. p. 189. p
- Ductility*, accounted for. 62. n
- Dying*, depends on chemistry. 203, 204
- Its subjects how prepared. 194. p
- See *Scarlet Dye*.
- Dysentery*, how cured. 172. p
- E.
- E Arth*, what. 120, 325
- Of two kinds. 120, 122
- Vulgar; defined. 122
- Whether a composition of sand and clay. 122. n
- Whether there be any simple or elementary earths. 122. n
- B 2
- Earth,

I N D E X

- Earth*, the basis of animals and vegetables. 161.
 & n. 166. 194. 30. p
 The basis of stones. 120
 How procurable pure. 167
 Incapable of vitrification. 167
 The same in all bodies. 167. 30. p
 Divided and classed. 122. & n. 123. & n. 325
 The compound species. 123. & n. 124. n
 Their analysis. 124
 The sealed earth. 123, 124
 The chemical principle, what. 176. n. 325
 Contain'd in air. 325, 326. & n. 327
 Whether perfectly elementary. 168. n
 Producible. 186. n
 Concerned in all chemical operations. 219
 Of the fossil kingdom. 325
 Its fixedness, simplicity, &c. 325, 326. 30. p
 Resists the alkahest. 325
 How obtainable, &c. 325, 326, 328
 Afforded largely by vegetables. 326
 Obtainable from foot. 327
 Whence obtainable from meteors. 327
 Procurable from oils. 327
 From alcohol. 327
 Afforded by animals. 327, 328
 The quantity contained in the human body. 327
 The same in animals as in vegetables. 328.
 322. p
 Producible from fossils. 328
 Gained from volatile salts. 328
 That obtained from water not pure. 326. & n
 Whether contained in metals. 328
 Not the same with the calces of metals. 328. n
 Its uses in natural bodies. 328, 329. 366, 367
 Its uses in chemistry. 329, 330
 The most immutable of bodies. 328, 329.
 30, 31. p
 The basis of all chemical vessels. 329
 Renders fixed salts volatile. 329
 The grand instrument of fixedness and vola-
 tility. 329
 Its use in distillations. 329, 330
 A great attractive of oil. 330
 Its use in purifying salts and spirits. 338
 Virgin, or philosophical, how procurable.
 24, 30. p
 Used as a dentifrice. 30. p
 Changed from land to sea. 286
 Periodical commotions in its parts. 297,
 298. n
Earthen-ware, how made. 316
Earth-quakes, whence. 328, 281, 285, 292, 272. p
 Artificial, producible by chemistry. 210, 211.
Ebullitions, what and whence. 241. n. 185. p
 Cold ones. 261. n
 Increasing the coldness of liquors. 184, 185. p
 Not in proportion to the strength of the alkali.
 185. p
Effervescence, what, and whence. 322. 327.
 328. p
 How produced. 327, 328. p
 Its kinds, &c. 327, 328. p
 The cold, hot and fiery. 327. p
 Requires water. 322
 Causing coldness. 184, 185
 Not found in the human body. 211. p
 See *Ebullition*.
Effluvia, may act without diminishing the
 weight of the body. 117
 May prove noxious. 240
 Of vegetables, variously affect the body.
 18, 19, 20. p
 See *Exhalations and Odours*.
Egg-glass, what. 375
 Its use. 375
Eggs, their yolk, what. 205. p
 White thereof, what. 358, 305. p
 Its office and use. 205
 Forms all the parts of the animal. 205. p
 How it appears to the senses. 205. p
 Is neither acid nor alkaline. 206. p
 How affected by acids and alkalies. 206. p
 Dissolves with a mild, but concretes with
 a stronger heat. 206. p
 How liquified and coagulated. 206. p
 Concretes in alcohol. 207, 208. p
 Distill'd per se. 208. p
 Its water by distillation, neither acid nor
 alkali. 208. p
 Solute virtue thereof. 208. p
 Is almost totally volatile. 208. p
 Distill'd 208, 209. p
 Putrified by digestion. 209. p
 Is poisonous. 209. p
 Its ill effects on the body, how reme-
 died. 209. p
 Their yolk and white, considered as men-
 struums. 358, 208. p
 How hatch'd by incubation. 206. p
Elaosacchara, how made. 107. p
 Their uses. 107, 108. p
 Their substitutes antiently. 107. p
Elasticity, what. 293
Elements in chemistry, what. 75. n. 176, 177
 Unchangeable, whence, and why. 174, 224.
 n. 225. n. 347. 366
 Their nature and office explain'd. 175, 176,
 177, 188. & n
 Whence denominated. 176. n
 A new definition thereof advanced. 176. n
 The common doctrine thereof overthrown.
 177. n. 189. n
 Their number. 176. n. 179. n. 187. n
 May be compound bodies. 180. n. 187. n
 Whence different in different subjects. 187
 Generally contain the medicinal virtues of
 bodies. 187. n
 Ele-

I N D E X.

- Elements in chemistry*, in what order they rise from bodies. 187. n
Whether dissolvable. 347. & n
Whether convertible into each other. 366
See *Principles*.
- Elixir*, the animal one, what. 226. p
Elixir proprietatis, its origin and history. 166. 168. p
Its virtues and uses. 168. p
The name, whence. 166. p
How made to advantage. 360; 166, 167, 168. p
How made with distill'd vinegar. 166. p
How made by *Paracelsus*. 167. p
The notion of its great virtue, whence. 166. 167. p
How to be made an universal medicine. 168. p
Prepared with alcohol and regenerated tartar. 172. p
Made with fixed alkali, its virtues and uses. 169. p. 167. p
How made with alcohol and fix'd alkali. 170. p
Its virtues and uses with alcohol and fixed alkali. 170. p. 171. p
Made with spirit of wine and soluble tartar. 171. p
A requisite caution in its preparation. 352
- Elixirs*, what. 190. 195. p
How made with spirit of vinegar. 166. 168. p
with distill'd waters and fixed alkali. 169. p
with alcohol and fix'd alkali. 170. p
with spirit of wine and soluble tartar. 171. p
with alcohol and regenerated tartar. 172. p
- Elliptic Furnaces*, their advantages. 380, 381
- Embalming*, how practicable to advantage. 103, 104. p. 139. p. 163, 164. p. 167. p. 171. p
- Emeralds*, how counterfeited. 116. 206. & n
- Emmenagogues*. 109, 110. p. 270. p
- Empyreum*, what. 125, 126. p
- Emulsions*, what and how prepared. 73, 74. p
How to be ordered. 74. p
Their preparation, analogous to that of the chyle. 74. p
With what cautions to be prescribed. 184. p
- Enamelling*, by whom invented and treated of. 20, 21
What and how performed. 202. & n. 203. n
- End*, defined. 191
- Ens Veneris*, what. 89
How prepared. 301, 302. p
How run into a liquor. 302. p
Its virtues and uses. 302. p
- Epilepsy*, its specific. 98
Medicines for it. 83. p
- Ercher*, (*Laz.*) his treatise on the metallurgia. 40, 41
- Essaying*, the art explained. 67, 68. 333
- Essaying Furnace*, what. 380
Its use. 380
Of what figure best made. 380, 381
- Ever-greens*, whence. 159, 165. p
- Exhalations*, what. 280
Whence noxious. 182
Of a compound nature. 283. n
Corrosive and various. 283. & n
Some wholesome. 283. n
Kindled in the air. 285. & n
- Experiments*, dangerous in chemistry. 37, 215. p. 315. p
Often unsuccessful from differences of fires. 268
In chemistry alterable different ways. 303
Instance of a fruitful or leading one. 186. p
- Explosions*, with chemical liquors. 210. & n. 259
& n. 184. p. 242. p. 261. p. 264. p. 327, 328. p
- Extracts*, what. 190. 155, 26, 27. p
Their nature and uses. 25, 28. p
How made. 25, 26. p
Two kinds thereof. 26. p
Whence inflammable. 27. p
From what subjects best procurable. 28. p
Essential, what and how made. 167. p
their virtues and uses. 167, 168. p
more efficacious than their subject. 168, 169. p
how converted into elegant powders. 168. p
with what cautions to be used. 168, 169. p
of saffron, how made, with its virtues. 167, 169. p
- Eyes*, made of glass. 207
- Eyes inflam'd*, a remedy for them. 114. p
Their disorders, how cured. 187. p. 310. p
- ## F.
- Fainting-fits*, how prevented by vinegar. 146. p
- Fatness*, whether and how curable in bodies. 72, 73, 74. p
- Le Febvre*, his treatise of chemistry characterized. 38
- Fennel*, virtues of its oil. 84. p
- Ferment of philosophers*, what. 42, 217
Universal, what. 217
Whether possible. 217, 218
- Fermentable bodies*, what. 117. p
Classed with regard to their fermentation. 118
p. 120. p. 122, 123. p
In what proportion they require ferments. 127, 128. p
- Fermentation*, its definition and cause. 115, 116. p. 129. p
Its difference from putrefaction. 116, 117. p
How to be raised and conducted in all subjects. 66. p. 117. p. 128. p. 130. p. 132. p
Its requisites. 321, 120. p. 122. p
Proceeds not in vacuo. 300. & n
The manner of its acting. 300. n
Fer-

I N D E X

- Fermentation*, how check'd. 299, 300. 121. n.
p. 122, 123. p. 132. p
- How rais'd and promoted. 299, 300. 66. p
122, 123. p. 131, 132. p
- Its phenomena. 128. p. 65. p. 129. p
- The time it requires. 130. p
- How known to be perfect. 66. p. 130. p
- Its surprizing force. 129. p
- Changes the oil of the subject into an ar-
dent spirit. 66, 67. p.
- Lessens the virtues of the remaining subject.
67. p
- Greatly alters vegetables. 67. p
- By attenuating the oils of vegetables, renders
them undistinguishable. 66, 67. p
- Absolutely requisite to the production of
inflammable spirit. 113, 114. p
- Supposed capable of dissolving the primary
particles of matter. 347. n
- Its difference according to the season, climate,
&c. 66. p
- The sole producer of inebriating liquor. 130. p
- Its poisonous nature. 129, 130. p
- May be spontaneous. 121. p
- Into what parts it divides the liquor. 121. p
- Alters the order wherein the parts of the
subject rise by distillation. 131. p
- Not found in the human body. 135. p
- Acetous, what. 142, 143. p
- How it proceeds. 143, 144. p
- Its ferments, or by what materials promoted.
142. p
- How checked. 144. p
- Its effects. 144. p. 146. p
- Its immediate cause. 176. p
- Ferments*, what. 117. p. 120. p
- The spontaneous, or natural, which. 121. p
- The heterogeneous, what and how made ar-
tificially. 121. p
- Whether any in the body. 123. p
- To what subjects and how to be applied.
127, 128. p
- Fertility of Land* whence. 124, 128. p
- Fevers* only intelligible by chemistry. 195, 197
- Medicines for them. 238, 239. p. 244. p
- Fewel* what. 262
- Not fire, nor convertible into it. 262
- Durable in proportion to its density. 262, 273
- Not destroyed by burning. 262
- Whence carried off in ignition. 262
- Oil the only one. 262, 263
- Of what and how made. 262. n. 263. n
- How chose best. 264, 265, 268
- Different kinds thereof, vegetable, animal, and
fossil. 263, 265, 268
- Vegetables which best for fewel. 265
- Other parts affected by the fire besides the
oil. 265
- Different kinds have different effects in che-
mical operations. 267, 268, &c.
- Which the purest and best. 267, 268, 273
- Filtration*. 26. p
- Philosophical, what. 49. p
- How performed. 99. p
- Filter* what. 26. p. 99. p
- Fire*, what. 219
- By whom and how first invented. 6, 7. n
- Antiently held a deity. 220
- Found in all bodies equally. 74, 219, 222,
223, & n. 227
- The universal instrument of nature. 219, 220
- Cause of all the motion and mutation in the
universe. 220, 221. n. 223, &c.
- Concern'd in every chemical operation. 219
- The only active principle in chemistry. 225
- Manner of its action. 224. n. 225. n
- The cause of fluidity. 220, 221
- Whether it be an original or a generated
thing. 220. n. 276. n. 230, 231, 233
- Why supposed producible by *Newton*. 234. n
235
- Whether owing to motion. 221. n. &c. 26
- Whether motion be essential thereto. 224. n.
225. n. 240. & n
- Its nature and properties. 233, 234
- Detained and fixed in bodies. 16. n. 92. & n.
217, 223. n. 247. n. 248. n. 251. & n.
252. & n. 275. 53. p. 54.
- Expands bodies in heating. 223. n. 224
- How it goes to compound metals. 100. n.
101. n.
- Its operation on bodies exposed thereto. 175,
188. & n. 275, 276, 346.
- Changes and compounds, not barely separates
bodies. 175, 188. & n. 275
- No universal resolver. 177. n. 179. n. 275, 276
- Whence its power of analysing. 179. n
- Made to burn under water. 210
- How far improveable to the purpose of war.
210. & n. 211, 212.
- Made inextinguishable. 210. & n
- Made to resemble lightning. 212
- How struck by collision. 224. n. 232. n. 234. n.
249
- Changes not the elements of bodies. 225. n.
- Of two kinds, elementary and vulgar. 225
- Vulgar, which. 226
- Elementary, which, and where found. 226
- May exist without heat and light. 225, 226,
227. 239.
- Whence its power of burning. 226, 230. & n
- Experiments to shew it equally present in all
bodies and all places. 226, 227, 230, 231,
232, 235, 236
- Naturally vague. 240
- Its quantity of heat how increased. 243
- Its absolute quantity indeterminable. 243
- Fire*

I N D E X.

- Fire*, how determined by the sun to the earth. 243, 244
 In what direction. 245
 Whence different in different places. 235, 238, 239, 240, 259. n
 How rendered active. 230, 231
 Its utmost effect in vitrification. 231, 232
 Visible only when collected. 232, 235
 Whether it have its magnet. 235, 236
 Its sources. 236
 In the centre of the earth. 236. & n. 237. n
 How collected divers ways. 238, 239, 258, 559
 Collected by the sun. 238
 How lost by night. 238, 239
 Contained in ice. 224, 240
 Has a certain magnitude and figure of its parts. 247. n
 Acts on bodies in proportion to their resistance. 248
 Its share in rarefactions, vegetations, &c. 248, 249
 Is corporeal. 250, 251, 253
 Its nature in what sense explicable. 250
 Made to drive a body circularly. 251
 Passes thro' the smallest orifice, and penetrates even gold. 253
 Is the most solid of bodies. 254
 The most polite. 254
 The simplest and most similar of bodies. 254, 255
 Its diversities. 255, 258, & n
 How procured by attrition. 249, 258, 260. & n
 By the putrefaction of vegetables. 258
 The mixture of chemical liquors. 259. & n
 The contiguity of air. 259
 Not properly fixed in phosphorus. 260. n
 Its quantity always the same in the world. 261
 How extinguish'd, and in what law. 262, 268
 How extinguished spontaneously. 270, 296
 Whence it requires fewel. 262
 Oil its only fewel. 262, 263
 The ways of preserving it. 262. & n
 Whether the same with sulphur. 263. n. 264. n
 Differs with the fewel employed. 268
 May have different effects from the manner of its being blown. 268
 How increased by water. 269. & n
 By what means intended or remitted. 269. & n. 271
 How affected and varied by air. 269. & n. 270
 Producing in vacuo. 210. & n. 259. & n. 269. & n. 270 & n
 Why increased by bellows. 270
Culinary fire, what 270
 How to be directed and used in chemistry. 271, 377, 378
 Its force whereon depending. 271
 How estimated and regulated. 271, 272
 Measured by the thermometer. 271, 272
 Its five degrees, and their several uses. 272, 273. & n
 The degree varied five ways. 273, 274
 In what ratio it is with regard to its distance. 274
 Acts strongest in conjunction. 274
 Which the gentlest. 275
 How applied in chemistry. 273, 275, 276, 378
 May have opposite effects in the same degree. 276
 Has different effects as differently applied. 276, 278
 Its productions not simple. 276
 Volatilizes fixed, and fixes volatile bodies. 276
 The sum of what is known thereof. 276
 Its use in the composition of the atmosphere. 280
 Its share in the action of menstrua. 242
 Its action on what bodies greatest. 346
 The manner of its action. 360
 How it acts on pure mercury. 360
 Its office according to *Paracelsus* and *Helmontius*. 366, 367
 Its power of destroying the virtues of vegetables. 43. p
 Of making acids. 240. p
Fire of suppression what. 94. p
See Light.
Fire-works owing to chemistry. 211
Fixedness, its meaning in chemistry. 63
 No body fix'd in nature. 65, 302. p
 Whence. 291. n. 329, 187. p
Flame, what, according to *Newton* and *Homburg*. 225, 234. n
 Not fire. 225. n
 Its kinds. 225. n
 Whereof it consists. 265
See Fire and Heat.
Flowers, of vegetables, what. 148, 149. n
 Their office. 148, 149. n
 Their juices. 154
 How destroyed by bruising. 17, 18. p
 Their odour whence. 104, 17, 18. p
 The more odoriferous, the less oil they afford. 84. p
 How best treated for their essential oil. 84. p
 Virtues and uses of their oils. 84. p
See Vegetables.
Fluidity, what. 223. & n
 Wherein it consists. 222, 223. & n. 228. n. 309, 310. & n. 187. p
Fluids, their different heats when boiling. 272. & n
 May lie concealed in solids. 155. p
Fluor Albus, its remedies. 163. p
Flux, in foundery, what. 255. p
Fomen.

I N D E X.

- Fomentations*, why not to be applied hot. 207. p
Fetus in the uterus, a vegetable. 164. & n
Fossils, what 53. 54
 Divided into simple and compound 54
 The simple, which 54
 The compound which 54
 Class'd. 54. 141
 Their principles. 139. 141. 187. n. 188. n
Freezing, how effected. 222
 How promoted by fire. 235. 261
Frit, what. 140. n
 Its kinds. 140. n
Frost, its effects on the earth, superficial. 284
 How it makes the earth fruitful. 284
Fruit, to retard its growth, and preserve it on the tree. 146. n
 Its use and office to the feed. 155
 How to preserve it unaltered. 300
 How prepared for fermentation. 127. p
Fulmination explained. 167
Fumes in vacuo. 241. n
Fuming of ores, what. 170
Furnaces, what. 377
 Their properties and apparatus. 377. 378
 Perform a double office. 377
 Which the best. 377. 378. 381
 That for the cold still, its structure and use. 379. 380
 The hot or common one for distillation, its structure, &c. 380
 Several kinds thereof. 378. 381
 How improvable. 380. 381. & n
 A knowledge of 'em, how procurable. 381
 G
Galien, his ignorance in chemistry. 196. 198
Gall, whereof it consists. 359
 Considered as a menstruum. 359
 Its use in the body. 359
Gangrenes, how stopped. 48. p. 51. p. 213.
 214. p
 Their spreading nature, whence. 214. p
Geber, his history, writings, &c. 13. 14. 15. 42
Gellies what, and how made. 25. p. 27. p
 Their nature and uses. 27. 28. p
Gems, what. 114
 Their origin, criterions, &c. 115. 116. n.
 117. 118. n. 120. 121
 Divided into transparent, brilliant; and semi-transparent. 114. & n
 Divided with regard to their colour. 114. n
 Diamond, why the chief thereof. 115
 Their variety whence. 115
 Of what composed. 115
 How form'd in the earth. 115. 116. n. 119.
 120
 How distinguished from their counterfeits. 115. n. 116. & n
 Their medicinal virtues. 116. n. 117
 Naturally tinged with mineral juices. 116. n
 The same kind have different colours. 116. n.
 Their colours discharged. 119
 Yield a tincture. 117. 119
 Whether digestible in the body. 117
 Whence transparent and opaque, &c. 119. 121
 Whence of determinate figures. 118. n. 119.
 120
 Their texture and grain whence. 119
 Including foreign matters. 119. 121
 The art of making or counterfeiting 'em, what. 205
 Whence it is imperfect. 116
 To counterfeit 'em in glass. 206. n. 207. n
 Best made from glass of lead. 207. n
 Gilding with gold, the manner of it. 63. n.
 74. 207. p
Glazer, his treatise of chemistry character-ized. 38
Glass defined. 138. 205. 45. p
 Of what class it is. 138.
 Pliny's account of its being made malleable. 12
 Its specific gravity. 58
 The excellency of its art. 104
 Owing to chemistry. 204. & n. 205
 Its rise and progress. 204. & n
 Never native, but factitious. 138. n
 Increased in weight by the fixed salt. 138. n
 Salt found therein in substance. 138
 Its principal properties. 138
 How it is made. 139. n. 204. 205
 How blown. 104. n
 How fashion'd and made fit for use. 140. n
 Whence green. 205
 Whence white. 205
 Whence dissolvable by contained liquors. 205
 How made of a sea-green. 206. n
 Of an emerald colour. 206. n
 Of a turcois colour. 206. n
 Like jasper. 206. n
 Of a gold yellow. 206. n
 Of a granat colour. 206. n
 Of a sapphire colour. 206. n
 Of a black colour. 206. n
 Of a snow white colour. 206. n
 Of a marble colour. 206. n. 207. n
 Of a deep red colour. 207. n
 Of various colours, equal to gems. 207
 Into porcelain. 207
 Engraved stones, how copied therein. 207. n.
 208. n
 Has a kind of atmosphere. 250. n
 Corroded by the air. 283. n
 Of lead, how made. 278. 279. p
 Its uses. 279. p
Glauber, his character and writings. 41
 His way of curing putrified meats. 213
 God-

I N D E X.

- Goddard's drops*, what. 219 p
Gold, its chemical character explain'd. 56, 57
 Its simplicity and perfection. 56, 57, 67
 Its specific gravity immutable. 58, 59, 61, 62
 Its great porosity. 61 n. 66
 Its malleability. 62
 Impervious to light and spirit of wine. 62
 Its immense ductility computed, with the cause thereof. 62, 63 & n
 Its divisibility. 63
 Is free from sulphur. *ib.*
 In what proportion used to gild silver. 62
 Its fixedness in the fire, whence. 63, 64, 227
 Rendred volatile with additions. 64 n. 77, 316 p
per se. 64 & n. 280, 281, 335 & n
 Exposed to a burning-glass. *ib. ib.*
 Recover'd after calcination. *ib. ib.*
 What force of fire required to fuse it. 65 & n
 Its solvents. 65 & n. 66, 302
 Attractive of mercury. 66
 Withstands both lead and antimony in cupellation. 66
 To try its purity and reality. 67, 68
 Its found, whence. *ib.*
 Supposed harder to destroy than make. 68
 Destroyed. 68 n. 100 n
 Philosophical, what. 68
 Found in three forms, but seldom pure. 69 & n. 70
 Its ore, and how dissolved therein. 59, 61, 69 & n
 How separated from the ore. 70, 71 & n
 How made by nature. 103
 Found in a ruddy earth. 123 n
 How far changeable by art. 173, 174
 How vitrifiable. 64 n. 65 n. 193
 How made pulverable. 193, 298 n. p
 Pure, how fitted for use. 209, 298 n. p
 The several ways of making it. 215
 Contained in all metals. *ib.*
 Whether its growth be from lead. *ib.*
 Made from silver. *ib.*
 How best made. 215, 216
 Requisites to the making thereof. 216, 217
 The art of making it, when first, and by whom pretended to. 10, 12
 Made by *Caligula* from orpiment. 11 & n. 12
 Obtainable various ways, with and without profit. 12 & n. 69 & n
 Composed of mercury and sulphur. 16 & n. 64 & n. 75
 Reconvertible into running mercury. 101 & n
 Extracted from sand. 41 & n
- Contained in earth, salt, sulphur, &c. 41, 42
 Made by several persons. 44 n
 Made from mercury, antimony, &c. 44, 45, 100 & n. 101 n. 102
 Gained from lead. 81
 How separated from silver. 85 & n
 Whence its colour and weight. 101 n
 Whether penetrable by mercury without increasing its bulk. 61 n. 66
 Whether subject to rust. 71, 302
 An inquiry into its medicinal virtue. 71, 72 n
 Who first imagin'd it medicinal. *ib.*
 Purgative, whence. 72 n
 Made diaphoretic. *ib.*
 Rendred potable by *Moses*. 78
 Its sulphur of no peculiar virtue. 72 n
 How dulcified after solution. 323
 A sham tincture of it, how made. 352, 353
 Its real tincture, how extracted. 264 p
 The more useful experiments made upon it. 298 n. p
- See *Aurum Potabile*.
- Gold Dust*, where found. 69
 Often adulterated by the negroes. 69
Golden Powder, what. 168 p. 172 p
Gonorrhoea virulenta, a good injection therein. 102 p
Gout, remedies for it. 47 p. 156 p. 275 p
Granadoes improved. 210
Gravity, specific, not precisely determinable in bodies. 59
 The criterion of metals. 54, 104, 132 n
 precious stones. 115
 Its effect in the action of menstrooms. 347
Grotta del Cani, its effect. 281
Guaiacum, its analysis. 179 n
 The solutive power of its acid spirit. 355
 Virtue of its rosin. 166 p
 How best treated by decoction. 23, 24 p
 How treated to advantage by distillation. 68, 69 p
Gums, what. 160 & n. 9 p
 Whence. 93 p
Gum Hedera, how made into tincture. 162 p
Gum Lac, to extract its tinctures to advantage by distillation. 252
 Nature and virtues of its tincture. 162 p
Gummo-Rosin, what. 160
Gun-powder, by whom invented. 17, 209 & n. 210
 A chemical production. 209 & n. 210
 Its composition. 209 n
 How prepared. 209 n. 238 p
 Its explosion accounted for. 209 n. 210 n
 How rendred more powerful. 210 & n
 Generates air. 290
 The hint of its contrivance. 238 p

I N D E X.

H.

- H** *Artshorn*, of uncommon hardness. 306
Hay-stacks, whence fired spontaneously. 176 p
Health, whereon it depends. 33 p
Hears, not essential to animals. 163
Heat, its nature. 230 & n
 Its quantity, as the weight of bodies. 74, 75, 78
 And flame from the mixture of cold bodies, whence. 212 & n
 Whether it be the same with motion. 221 n.
 233 n
 How caused by fire. 229, 241
 No measure of fire. 230
 Whereon it depends. 230 n. 232 n
 What in the hot body. 230 n
 Whether producible by motion. 231 & n.
 232 n. 233 n. 234 n
 Caused by ice. 240 n
 Its requisites. 232 n. 233 n. 242 n. 244
 Its direction all ways. 233 n
 Defined by the Lord Bacon. 233 n
 Subterraneous, whence it may proceed. 237 n
 Independent of light. 239 & n. 240 n. 241
 How rendered perceptible by the sun. 241, 242 & n
 In what proportion conceiv'd and increas'd, &c. 242, 243, 262, 274
 Depends not immediately on the sun. 244, 279
 In what proportion to the obliquity of the rays. 244, 245
 Variable divers ways. 245, 246
 Produced by friction various ways. 249 & n.
 250 & n
 by sulphur and iron filings. 211, 212 & n. 260
 by salt of tartar and water. 260 n
 In mines, whence. 236 & n. 237 & n. 261
 Produced by a mixture of cold bodies. 260 & n
 Of the weather, whereon it depends. 285
 Caused by water. 322 n
 How it may hinder dissolution. 346, 347
 In what degree prejudicial to the human body. 207 p
 Coagulates the animal juices. 206, 207 p
 A knowledge of its effects requisite to a physician. 209 p. 211, 212, 213 p
 May cause surprising alterations in animal matters. 209 p
 Cures effected by it. 213 p
Helmont (J. B. Van) his history. 30, 36
 His birth and education. 30
 Created doctor in physic. 36
 Doubts the foundation of the whole art. 31
 Commences chemist. 36
 His chemical discoveries. 36
 Turns all medicine into the vein of chemistry. 32
 His writings, &c. 33
 His death, character, &c. 33, 35, 36
 The judgment to be formed of him. 33, 36
 Not possessed of the universal medicine. 33, 36
 His *Archæus* explain'd. 33, 34
 Fail'd in the cure of several diseases. 34
 How he treated his own illness. 35
 His notion of the alkahest. 359, 362, 365, 372
 Summary of his philosophy. 366, 367
 (Mercury) his character. 32, 33, 36, 369
 His opinion as to the alkahest. 369
Hepar of Antimony, how made. 309 p
Hermes, held the inventor of chemistry. 2, 8
Trismegistus, who. 2, 3, 8 n. 9
Hermetic art, what. 9
Herrings, whence they turn red in curing. 96 p
Hieroglyphics, the manner of writing therein. 56
Hippocrates, his imperfection as a physician. 195, 199
 Wanting in the pathology. 195
 semeiotics. 196, 197
 therapeutics. 197, 198
 Unacquainted with chemistry. 198
Hollandus (John and Isaac) their history, writings, and inventions. 20, 21
Homburg, his history. 48, 49 n
 His character and writings. 47, 48, 49 n
 His experiments. 16 & n. 351, & alibi passim.
 Borrow'd from Bacon. 16
Honey, what, and how procured. 154, 155 n
 119 p. 114 p
 Contains iron. 155 n
 Its kinds. 155 n
 Consider'd as a menstruum. 359
 Distilled before fermentation. 114 p
 How prepared. 114 p
Hops, their medicinal virtue. 214 n
 Why added to beer. 114 p
Horfe-dung, how made to afford fire for chemical uses. 258 & n
 Its fire, of what kind. 258
Horus, probably the same with *Vulcan*. 7
Humectation, the force it gives to menstrooms. 335, 336
 Natural and artificial. 336
Hunger, whence and how it proves mortal. 216 p
Hungary Water, what, and how made. 173, 174 p
 Its virtue and use. 174 p
 174 p
 174 p

I N D E X.

- Huygens's Vacuum*, how made. 226
Hydragogues. 158, 159 p
Hygiene, what. 197
 Depends upon chemistry. 197
Hypochondriacal Disorders, medicines good therein. 41 p. 163 p. 182 p
Hyssop, what. 9
Hysterical Disorders, remedies therein. 41 p. 47 p. 84 p. 109 p. 163 p. 174 p
- I.
- I**alap, its tincture, how best extracted. 157, 158, 159 p
 Its rosin, whence more or less purgative. 159 p
Jaundice, medicines for it. 182 p
Ice, whence, and how produced. 221, 222 & n. 309 & n
 Contains fire. 224, 240
 Lighter than water. 222 n
 Made to heat cold liquors. 240 n
 Formed in the heavens. 285
 How made spontaneously. 298
 How it bursts containing vessels. 298, 299
 How produced. 309 & n
Fet. what, and where found. 128 & n
Jewels, what. 114
 Three kinds thereof. 16.
 See *Gem*.
Incubation, its use. 206, 207 p
Indigo, what, and how prepared. 203 & n
Infants of the wealthy, whence so often sickly. 185 p
 Their diseases curable by a proper treatment of the nurse. 185, 186 p
 Their disorders from an acid cause, how known. 185 p
 From an alkaline cause, how known. 16.
 Their peculiar disorders, how cured. 287 p
Inflammability, whereon it depends 263, 264, 265
Inflammable Bodies, how formed. 262 n. 263 n
Influences of the celestial bodies, whence. 278 n
Infusions, what, and how made. 20, 21 p
 What parts of vegetables they contain. 21, 23 p
 How they differ from decoctions 23 p
 How made to best advantage. 23 p. 25 p
 The subjects best fitted for them. 24, 25 p
 How administred. 16.
 Carry the virtues of simples into the blood. 25 p
 See *Decoction*.
Inks, their general basis. 264 p
 For printers, of what made. 53 p
Instruments of Chemistry, what. 218, 372
Joannes de Rupe Scijsa, his writings. 20
 Imprison'd for a magician. 20
- Iron*, its chemical character. 56, 57
 Its nature. 57
 Its specific gravity. 59, 91
 Generated by art. 60 n. 95 n
 Afforded by all vegetable and animal ashes. 60 n. 93, 269 p
 Obtain'd from clay and all other bodies. 60 n. 93, 95 n
 Producing by mixture and by fire alone. 60 n
 Its composition. 60 n
 Unites not with mercury. 70, 74, 77
 Why it mixes with sulphur and tin. 80 n
 Its brittleness, whence. 91
 How made into steel. 91, 92 & n
 How case-harden'd. 91 n
 Its fixedness. 91 n
 Very sulphureous, but capable of being deprived of its sulphur. 91, 92
 Hard of fusion. 92
 Made ductile by ignition. 92
 Increas'd in weight and bulk by ignition. 92 & n
 Its solubility. 92
 Its rust, what. 92, 93
 Changes colour according to the menstruum. 93
 Volatilizes with lead and antimony. 16.
 The only magnetical metal. 16.
 How it gains a polarity. 93 n
 Whether the cause of the stone in the bladder. 94
 How work'd from the mine. 56, 94 n. 95 n
 Its ore, various. 94 & n
 How temper'd when too brittle. 94 n. 96 n
 In some countries prefer'd to the nobler metals. 94 n
 Made with mud and sulphur. 95 n
 Its criterion. 16.
 Its medicinal virtues. 16.
 Approaches a vegetable nature. 263 p. 269 p
 How turn'd to vitriol. 264 p
 Given crude in some cases. 265 p
 Its tincture or potable vitriol, how made. 265 p
 Virtues and uses thereof. 265, 266 p
 Its vitriol how reduced to a calx. 266 p
 How run into oil. 267, 268 p. 271 p
Valentine's golden tincture thereof. 268 p
 Virtues and uses thereof. 268 p. 269 p. 270 p
 Its solution or tincture in *Rhenish* wine, how made. 16.
 Its solution or tincture with vinegar. 270 p
 Virtues and uses thereof. 270 p
 Sublimed with sal ammoniac. 270, 271 p

I N D E X

- Iron*, its flowers how obtain'd. 270 p
 Virtues and uses of its flowers. 271 p
 A magnet with regard to acids and sulphur. 271 p. 307 p
 Destroy'd by sulphur. 272 p
 How calcined. 272 p
Iron-bars, how dexterously saw'd asunder. 349 p
Island, crystal, what. 255 p
 How it affects the rays of light. 255 n.
 256 n
Issues, how made by caustic. 48 p. 224 p
Itch, how cured. 989 p. 290 p. 291 n. p
Julces of Plants, their difference. 9. 10. 11 p
 How clarify'd. 26. 27 p
 Fluid and inspissated, how fitted for fermentation. 127 p
Juniper, virtues of its oil. 83 p
- K.
- K** *ALI*, what. 339
Kelly, his history. 45. 46 n
Kibes, how prevented and cured. 103 p
Kidneys, their office and use. 189 p. 216 p
Killing, how understood in chemistry. 320 p
Kingdoms, body justly divided into three. 53
- L.
- L** *AC Sulphuris*, how made. 262. 263 p
 Its virtues and uses. 263 p
Lac Virginale, what and how used. 158 & n. p
 Metalline, what and how used. 275 p
Lacca for Painters, how made. 200 & n. 201 & n
 Its kinds. *ib.*
Land, how render'd fruitful. 124
Lapis Aetites, what, and where found. 137 & n
 Its structure. 137 n
 Ferruginous. 137
Lapis Armenus, what, and where found. 136 & n
Lapis Calaminaris 133 & n
 How obtain'd. *ib.*
Lapis Hamatites, what, and where found. 137
 8 & n
 Its uses. 137
 Whether it yields iron. 137
 Its kinds. 137
Lapis Infernalis, what. 348. 281. 282 p. 284 p
 How made. 281 p
 Its effects and uses. 282 p
 Whence it loses its force in the fire. 284 p
Lapis Lazuli, what, and where found. 136
 Distinguish'd from *Lapis Armenus*. 136 n
Lapis Stellatus, what. 136
Lavender, virtues of its oil. 83 p
Lavignon, what. 165 n
 Manner of its motion. 165 n
Laxatives. 153. 154 p. 182 p
- Lead*, its chemical character. 56. 57. 58
 Its nature. 57. 58
 Nearly allied to silver. 58. 276 p
 Its specific gravity. 59. 78
 Two kinds thereof in chemistry. 66. 82
 The chemical names for it. 66. 80
 Whence call'd *Saturn*. 80. 81. 273 p
 Its use in cupellation. 66. 81
 Turns to glass therein. 79. 80
 Suspends all bodies but gold and mercury. 78
 Approaches to and yields mercury. *ib.*
 Mixes only with mercurial metals. *ib.*
 Its softness. *ib.*
 Easiness of fusion. 78. 273 p
 Incapable of ignition. 78. 273 p
 Its distinguishing properties. *ib.*
 Its penetrative and dissolving nature. 78. 79
 Resolvable into scoria and mercury. *ib.*
 Readily vitrified. 79
 Easily recover'd from its calx. 79 & n
 Dissolves sweet in weak acids. 79. 278 p
 Its use in obtaining and separating gold and silver. 79. 87
 Volatilizes every thing but gold and silver. *ib.*
 Its solvents. *ib.*
 Absorbs metals, and nothing else. 80
 To convert the glass of lead again into metal, a *desideratum*. 80
 Its sound. 81
 Unelastic. *ib.*
 Ally'd to, and converted into gold. 43 n. 81
 Not sufficiently known. 81
 In what forms found. 82. 123 n
 How gain'd from its ore. 82 & n
 How calcined. 274
 Increas'd in weight by calcination. 101
 Dissolv'd and turn'd to ceruse by vinegar. 272. 273 p
 Poisonous quality thereof. 273 p. 276 p
 Its solution in distill'd vinegar. 275
 How turn'd to oil. 275 p
 Virtues and uses thereof. *ib.*
 Its vitriol, how procur'd with distill'd vinegar. 276 p
 Its incrated oil, what. *ib.*
 Its vitriol with *aqua fortis*. 277 p
 Virtues and uses thereof. 277. 278 p
 Its balsam with oil of turpentine. 278 p
 Its conversion into glass. 278. 279 p
Leaven Rakers, what. 121 p
Leaves of Plants, what. 148. 153
 Their nature and office. 148. 154
 Their juices. 159. 160
Lees, what. 121 p
Lemery (the elder) his history. 38. 40 n
- Le-

I N D E X

- Lemery*, his treatise of antimony borrow'd from
Basil Valentine. 22
 His course of chemistry, &c. characteriz'd. 38, 39 n
- Lewis XIV.* an instance of his generosity. 210 n
- Life*, by what means lengthen'd. 163 p. 166,
 167 p
- Light*, what it is. 241
 According to *Newton*. 234
 Whether original or producible. 221 n. &c.
 Its universality. 222 n. 262 n. 263 n
 Visible and invisible. 227, 228 & n. 239
 Its sensation, how produced. 228 & n
 In motion. 257
 Depends on fire. 228 & n
 A single ray divisible into seven others of
 different colours, &c. 228, 255
 Its motion rectilinear. 228 n
 Produced from bodies sensibly cold. 229
 How allied to heat. 229
 Fixed and detained in bodies. 16 n. 101 & n
 Its share in the composition of metals. 100
 & n. 101 & n
 A hard and solid body. 173 n
 Whence in putrified fish, &c. 230
 Affected by bodies at a distance. 236 n
 Independent of heat. 239 & n
 How it produces lustre. 241
 How alter'd by the atmosphere. 245
 How obtain'd by friction from glass. 248 n.
 249 n
 Passes uninterrupted thro all bodies. 254
 The sides of its rays have different powers.
 255, 256 n
 Its phenomena in passing thro island crys-
 tal. 256
 Differently refrangible and reflexible. 256
 Its reflexion, whence. 256 n
 Its fits of easy reflexion and transmission,
 256 n. 257 n.
 How affected in passing thro different me-
 diums. 256 n
 Its velocity. 257 & n
 Its different kinds. 278 n
 Different tinctures. 278 n
 See *Sulphur*. See also *Fire*.
- Lightning*, imitated by chemistry. 212
- Lime*, its effects in the body. 191, 192 p
 In what cases to be used medicinally. 192
 Why pernicious in hot, but serviceable to
 chronical diseases in cold climates and
 constitutions. 192 p
 How made. 316
 Contains much fire and water. 316, 51,
 52 p
- See *Quick-silver*.
- Lime-stone*, what. 316, 53, 54 p
- Liquors*, how made cool and pleasant in hot
 countries. 244 p
- Lifter, Martin*, his notion of the stone's being
 producible from the iron taken in with
 the food. 194
- Litharge of gold and silver*, what. 80
 Convertible to glass. 274 p
 Its kinds, &c. 274 p
- Lixivium, alkaline*, how made violently strong. 50 p
- Londstone*, what, and where found. 173 & n
 Its effects mimick'd by iron. 93
 Affords iron. 94, 137
 Effects of its effluvia. 117
 Its kinds. 137 n
 How weaken'd. 137 n
- Lobsters*, their shells, how form'd. 167
- Long Necks, chemical*, what, and their use. 375, 376
- Lullian art*, what. 18
- Lully (Raymond)* his history. 18, 19 n
 Introduced the transcendental art. 18
 His writings and discoveries. 18, 19 n
 His travels and fate. 18, 19 & n
 His water, what. 262 p
- Luna Cornea*, how made. 283 p
 How reduced to silver again. 283 p
- Luna fixa*, a contingent experiment. 44 n
 What. 284 p
 Nearly allied to gold. 284 p
- Lunar Cause*, how made. 281 p
- Lustre*, what and whence. 241 p
- Lutes*, what. 381
 Their use. 381, 382 n
 The common, how made. 381, 382 n
 In what cases used. 381
 Excellence thereof. 381
 The philosophical, of what composed. 381,
 382
 Its manner of use, &c. 382
 Substituted for it in some cases. 382
 For coating of retorts. 382, 383
 For stopping the cracks of furnaces. 382
- M.
- M**AD Dog, its bite, how cured. 213 p
- Magic*, what. 16, 17, 211
 How practicable by chemistry. 211, 212
- Magic-Lanshorn*, effects thereof. 212
- Magistery*, what. 189
 Distinguish'd from extract and elixir. 189
 How procured. 353
- Magnetism of iron*. 93 n
- Malleability* accounted for. 62 n
- Malt* how made. 214 n. 123 p. 124 p
 Distill'd before fermentation. 113, 114 p
 How and when best brew'd. 123, 124 p
 How

I N D E X

- Mals*, how treated in the coch. 124, 125. n. p
 Its difference from corn or barley. 125. p
 To check its too violent fermentation. 125. p
Malt-liquors are wines. 123. p. 126. p. 144. p
 How made to afford most spirit. 130. p
Malt-spirit, whence its foulness. 133, 134. p
 With what cautions to be distilled. 133, 134. p
Malsing, its rationale. 123, 124. p
 Its perfection, wherein it consists. 124. p
Manganese, what. 140. n
 Its use in glass-making. 140. n
Manna, what and whence. 153, 154, 159. p
 Its kinds. 154. n
 From what trees obtainable. 154. & n
Marble burst by frost. 317, 318. n
Marcasites, what. 132. & n
 How known from metalline ores. 132. n
 Their composition. 132, 133
 Abound with sulphur. 132. & n. 133. & n
 Sometimes contain metal. 133. n
 May be work'd to profit. 133. n
 Effects of their exhalations. 283. n
 Growing hot with water. 322. n
Marls, what. 123
Matrass, what. 375
 How made a circulating vessel. 375
Matter, its quantity known by its weight. 358
 How originally fashion'd. 374
 Whence unchangeable. 366
 See *Body*. See also *Element*.
Matthew's-pill, what. 179. p
Mechanics, what. 200. & n
 Their use in solving chemical phenomena. 170. & n. 174. & n
 Divided into rational and practical. 200. n
Medicated-liquors, how prepared. 109. p
 Their uses. 109. p
 How to be administred. 110. p
Medicinal virtues, criterion thereof. 264. p
Medicine defined. 194
 Improved by chemistry. 22, 30, 194, 199
 Its end. 194
 Its object. 194
Medicines portable, how procured. 28. p
 Their nature explained. 345
Melting-furnace, what. 380
 How best constructed. 380, 381
Memoirs of the Royal Academy, the chemical pieces therein. 49, 50
Menstruum, innocent, dissolving gems and stones. 117, 348, 349
Menstruum peracutum, what. 64. n. 65, 317, 318. n. p
 Its power. 64. n. 65, 348, 317, 318. p
Menstruums, what. 332
 Manner of their action. 314, 315. & n. 332
 Four conditions requisite to their acting. 344, 347, 350
 Act mechanically, and in what sense. 332
 Are dissolved in the act of solution. 332
 Have two kinds of action. 332
 Origin of the name. 333
 Act not in vacuo. 292, 296, 298, 299
 May act most effectually in form of fumes. 301. n
 The knowledge thereof important. 332
 Divided into solid and fluid. 333
 The solid which. 333, 334
 Metals are menstrooms to one another. 333
 Act not in a dry form. 335
 Dry ones, how brought to act. 335, 336
 The liquid or fluid which. 336, 342
 Of two kinds. 336
 The aqueous, which. 336
 The oleaginous, which. 336, 337
 The alkaline spirituous, which. 337
 The acid spirituous. 338
 The inflammable, which. 338, 339
 The fix'd alkaline, which. 339
 The compound saline, which. 339, 341
 Variously compounded and diversified. 341, 342
 An innocent one for the human calculus discoverable. 341, 342, 349, 361
 Some have an internal principle of motion. 342
 Some made to act by external force. 342
 Must be appropriated to the solvend. 342
 Must have a secret relation to the bodies they dissolve. 342, 343, 360
 Motion no criterion of their action. 343, 348
 Why all cannot dissolve all bodies. 344
 Whether an universal one be discoverable. 344
 Dissolve not always the better for being stronger. 344
 Their strength varies with the kingdom whence they were obtained. 345, 346
 Their action depends principally on fire. 346
 May have their action obstructed by heat. 346, 347
 Actually enter the solvend. 348
 Their force not to be estimated from the senses. 348
 Their actions never determinable *a priori*. 348, 354, 359
 Dissolving metalline and mineral, but not animal substances, &c. 348, 349
 Their action not regulated by the hardness or softness of the solvend. 349
 The alkaline generally dissolve such bodies as acids will not. 350
 The acid dissolve such bodies as the alkaline do not. 350
 The acid dissolves not equally. 350

I N D E X.

- Mensstruums*, the spirituous have their peculiar subjects. 350
- Rules for their application. 350, 359
- Some to be used preparatory to others. 350
- To determine the subjects for the aqueous. 351
- For the sulphurous and oily. 351, 352
- For the inflammable. 352, 357, 358
- For the alkaline. 352
- For the acid. 353, 256
- May be innocent, yet powerful. 341, 342, 349, 357, 360, 361
- If an universal one be obtainable from sea salt. 357
- A new set how procurable. 358
- Anomalous ones, which. 358, 359
- Their nature not determinable by their actions. 360
- Their power not absolute. 349, 360, 361
- The strongest not required for the hardest subjects. 361
- An uncommon one from rye bread. 361
- A mild one effecting extraordinary solutions. 361
- The change between them and the solvents generally reciprocal. 361
- Their strength sometimes impaired by rectification. 362
- Some must be exquisitely purified to make them act. 362
- Two principal ones possess'd by *Paracelsus*. 371
- How to be suited to the extracting of tinctures. 159, p
- How suited to the *Materia Chemica*. 159, & n, p
- Mercurius vita*, how made. 317, p
- Its metalline nature. 317, p
- Mercury* or *Faunus* whether the inventor of chemistry. 8, & n
- Mercury* what, and whether it be a metal. 55, 100, 182, n
- The basis of all metals. 55, 102, 182, n
- Whether procurable from all metals. 216, 351
- Penetrating gold. 63, n, 66
- Procurable without sulphur. 68
- Its use in separating gold. 70, 208
- Its gravity. 218
- Its purity and simplicity. 75, 76, 77, 182, n
- Its three different states. 75, n
- Virgin, what. 76, & n, 77
- Its kinds. 76, n
- How purified. 77
- Found in vegetables. 76, n
- Of the philosophers, what. 75, 76, 77
- Procured from lead. 78
- How it dissolves gold. 101
- How turned into gold and silver. 43, 45, n, 102, 182, n, 215
- Fixed by the fumes of lead. 102
- By fire. 276, & n
- Mercury made to yield a fourth of water. 176, n
- The principle, what. 176, n, 178, 181, n
- How destroyed. 182, n
- See *Quicksilver*.
- Mercury of metals*. 182, n, 218
- Of the philosophers. 75, 76, 77
- Metalline bodies*, to extract their tincture. 350
- Metallurgia*, what. 40
- Writers therein. 40, 42
- Metals*, of what they consist. 45
- Their definition, division, &c. 55
- Their apotheosis, or similitudes with the heavenly bodies. 55, & n, 56
- Their scale or characters. 56
- Their distinguishing property. 58, 99, 102, 132, n
- Their origin and formation. 59, 60, 61, n, 100
- May be generated artificially. 60, n
- Whether coeval with the world. 59, 60, n
- How produced in the earth. 60, n
- Grow and change in the mine, according as the earth is altered. 60, n, 61, n
- Which of 'em are fixed, and whence. 63, 301, 302, 328
- The imperfect abound with sulphur. 63
- How purged of their adhering sulphur. 255, p, 257, p
- How cupelled. 66
- Must lose their found to become gold. 67
- The perfect, what. 75, n, 100, n, 102, 103
- In fusion range not according to their specific gravity. 80
- The general doctrine thereof. 99, 104
- Composed of sulphur and mercury. 99, 100, 371
- Their analysis. 100, n, 101, 103, 351, 353
- Their principles. 100, n, 101, 103
- Their soul and body, what. 101
- What is wanting to purify them without loss. 126
- Convertible into vitriol. 135, & n
- How malleable. 208, 209, 255, p
- Fuse more readily at one time than another. 269
- Increase not in heat after fusion. 373
- Why so subject to rust at *London*. 288, 289
- Whether form'd of water. 316, 371
- Burst by frost. 318, n
- Soluble in water. 288, 298, p, 320
- Recoverable from their calces. 328, n
- The best *mensstruums* for each other. 333
- Their tinctures how gained. 340, 341
- Which dissolved by alkalies. 350
- Their action, whence. 284, p, 297, p
- Their nature varied, with the salts join'd to them. 284, p, 297, p
- How rendered potable universally. 264, p
- Me-

I N D E X

- Metals*, how reducible to powder, and reconver-
ted into metal. 267. p. 272. p.
- How run into oils. 267. p. 268. p. 271. p.
275. 276. p.
- How convertible to flowers universally.
271. p.
- Quickened and made active by sublimation.
271. p.
- Are attractive of acids. 278. p.
- Their different tastes in solution. 278. p.
- How convertible to balsam. 278. p.
- How reducible to glass. 279. p.
- How purified universally by amalgamation
and lotion. 297. p.
- What they deposit by lotion. 297. p.
- How rendered volatile, or turn'd to a butter.
316. p.
- How made poisonous. 316. 317. p.
- The pure induce little change in the men-
struum. 354.
- Made volatile by sal-ammoniac. 357.
- Their red tincture, what. 256. p.
- Meteors* whence, and what. 278. & n. 284. 285.
- Fiery, whence. 285.
- Milk*, what. 75. p.
- Its origin in the body. 72. p. 74. 75. p.
- Generated in men as well as women. 75. p.
- Whence apt to turn acid. 75. p. 183. p.
- How it commences animal. 75. p.
- Its nature, parts, kinds, &c. 181, 182, 183. p.
- Differs in goodness with the animal that af-
fords it. 181. p.
- Shewn to be neither acid nor alkali. 181,
812, 183. p.
- A kind of emulsion. 182. p.
- Sign of its putrifying. 183. p.
- From what animals, and on what occasions
apt to putrify. 183. p. 185. p.
- Strongly coagulated with acids. 183, 184. p.
- How made into cheese. 184. p.
- Its natural colour white, universally. 184,
185. p.
- Is disposed to turn red. 184, 185. p.
- Turn'd red by boiling with alkalies. 184, 185. p.
- Whence morbid. 184, 185, 186. p.
- Of Nurses, &c. how affected by a fever. 184,
185. p.
- How altered by an alkaline disposition of the
body. 185, 186. p.
- Readily convertible into blood. 186. p.
- Sign of its perfection. 187. p.
- Minerals* defined. 54. p.
- The notion thereof explained. 54. p.
- How formed in the earth. 112. n. 113. n.
- Generally unwholesome. 282.
- Their growth from water. 307. & n.
- See *Fossil*.
- Mineral waters*, whence. 311. & n.
- May be copiously diluted with rain. 311. n.
- Miners*, how affected in the quicksilver works.
77.
- In the silver mines, with a preservative for
the same. 86. n.
- How they live in the salt mines of *Wilisee*.
106. n. 107. n.
- Mines* what, and whence. 60. n.
- The signs whereby they are discovered. 61. n.
- Require due time to ripen. 61. n.
- The knowledge requisite to digging them.
59.
- Recruit in time after digging. 61. n.
- To enrich them again after working. 61. n.
- The direction of their veins. 61. n.
- Of gold, how worked. 69. n. 70, 71. & n.
- Gold mine of *Crimnitz*. 69. n.
- Of lead, how work'd. 82. & n.
- Of quicksilver, how work'd. 77.
- Of silver, where found. 85. n.
- Exhalations poisonous. 86. n.
- Of *Potosi*. 85. n. 86. n.
- Of copper, how wrought. 90. & n.
- Of iron, where found and how wrought.
94. n. 95. n.
- Of tin how wrought. 98, 99. n.
- Of salt how wrought. 106. n. 107. n.
- A knowledge of 'em depends on chemistry.
208.
- The heat found therein, whence. 236. & n.
237. & n.
- Taking fire at the flame of a candle. 237.
- Their fumes or damps what. 237.
- Their poisonous exhalations. 286. & n.
- Minium*, what. 19.
- How made. 274. p.
- Wherein it differs from litharge. 274. p.
- Antiently used as a fucus. 275. p.
- Its virtues and uses. 275. p.
- Mint*, virtues of its oil. 83. p.
- Mint-water* cohobated, its virtues. 64. p.
- Miracles* performable by chemistry. 211, 212,
213.
- Mirrors* made in walls. 257.
- Of wood. 257.
- Of straw. 258.
- See *Burning-Glass*.
- Moon-light* collected, without heat. 239.
- Le Mort*, his chemical writings characterized.
40.
- Mortar*, what. 316.
- Mortifications* how stopped. 48. p.
- Mosses*, what. 266.
- Mother, of soap-boilers*, what. 176. p.
- Motion*, what, and how requisite to action. 171,
172. & n. 173. n.
- Whence caused in bodies. 248.
- Its effects, what. 172. n.
- Produced by gravity and attraction. 172. n.
- Whence constant in the universe. 299.
- Mo-*

I N D E X

- Motion*, particular principles thereof in some bodies. 342
 See Fire.
- Mountains*, their tops, whence covered with snow. 246, 285
 High ones, whence undisturb'd at their tops. 301
- Mulsun*, what. 114. p
 Its virtues. 114. p
 Of its distill'd water. 114. p
- Mummy*, whence preserved in that state. 322
- Mundic*, what. 99. n
 How clear'd away from its tin-ore. 99. n
- Museums*, the collections for them class'd. 54, 138
- Mussels*, their anomalous nature. 163. n. 164. n
 Differ greatly from other animals. 164. n
 Generate within themselves. 164. n
 Their manner of walking. 164. n. 165. n
 Their arms. 164. n
 Growth of their shells. 166. n
- Pond-mussel*, manner of its creeping. 165. n
- Sea-mussel*, manner of its motion. 164. n
- Must*, what. 25. p. 135. p
 How preserved. 129. p. & n
- Myrrh*, its tincture, how best made. 161, 162. p
 With spirit of wine. 312
 Virtues and uses thereof. 163. p
 Soluble with the white of an egg. 358
 Crude, dissolves not in the body. 163. p
- N.
- N** *Aphtha* what, and where found. 128.
 Its inflammability. 129
 Differs from *Oleum Terra*. 128
- Natron* what, and whence procured. 109. & n. 110. n
- Natural philosophy*, what. 192
 Its parts. 192
 Its office. 192
- Nature*, what. 223
- Nervous diseases*, why not easily curable. 39. p
- Nitre*, its properties. 108, 234. p
 A natural salt, and how procured. 109. & n. 108. 109, 234. p
 How purified. 109. n. 111. n.
 Its origin and history. 108. & n. 109. & n. 233. 234. p
 Whether the antient were the same with ours. 108. n. 109, 234. p
 Whence the modern is all obtained. 109. n. 233, 234. p
 Of four kinds. 109, 233, 234. p
 Whether fossil, animal or vegetable. 108. n. 109. n
 Producible by art. 109. n. 183. n. 110. & n. 111. n. 340, 234. p
 To prevent its fusion. 84
 Egyptian, whence produced, and its affinity with ours. 109. n. 110. n
- Approaches sal-ammoniac*. 110. n
 How render'd inflammable. 236. p
 Is not naturally inflammable. 234. p. 237. p
 Its medicinal virtue. 234, 235, 236. p
 How purified by crystallization. 235, 236. p
 How made a beautiful red salt. 236. p
 How converted into fix'd alkali with tartar. 236. p
 Totally volatile in distillation. 340
 Its spirit how prepared. 84
 Regenerated from its spirit. 340
 Its affinity with vegetable salts. 236. p
 How made into fix'd alkali with charcoal. 237. p
 Made into sal prunellæ. 238. p
 Into *Sal polychrestus*. 238, 239. p
 Its spirit with bole, how made, &c. 239. 240. p
 How rendered totally volatile, or converted into acid spirit. 240, 241. p
 Glauber's spirit thereof how made, &c. 241. p
 Convertible both into acid and alkali. 241. p
 How regenerated fix'd, from its spirit. 243. p
 How regenerated semi-volatile, with sal-ammoniac. 243, 244. p
 How made acid, or impregnated with its own spirit. 244. p
 Vegetative, how made. 244, 245. p
 Retains its nature in the spirit thereof. 284. p
- Nitrian waters*, what. 109. n
- Nitrum antimoniatum*, how made. 313. p
 Its nature and uses. 313. p
- Nitrum nitratum*, what, and how made. 244. p
 Its uses. 244. p
- Nurses*, how to be regulated with regard to their milk. 185, 186. p
 How to be chose. 186. p
- Nutrition*, its immediate matter, what. 181. p. & n. 210. p. 216. p
- O.
- O** *Culus mundi*, alterable by water. 117
 Odours, alterable by the air. 279, 280. n
 Of vegetables, whence. 154
 Their influence on the human body. 18, 20. p. 224. p
 Producible from inodorous bodies. 23. p
 How recoverable in perfumes. 156. p
 Instance of mortal ones. 202. p. 209. p. 211. p. 224. p
 The chemical doctrine thereof. 328, 329. p
- Offa alba*, its nature, virtues, and uses. 225. p
 How made. 225. p
 Its efficacy as a *Menstruum*. 342, 357
- Oil*, of what composed. 60. n
 Its use in the composition of bodies. 30. p
 Its use in the feed of vegetables. 158, 71. p
 In wood. 90, 91. p
 Its embalming and preserving virtue. 158
- D
- Oil,

I N D E X.

- Oil*, essential, why so called. 158. p
 Vegetable, what. 159
 Animal, its nature and character. 169, 221, 224. p
 But one in nature. 222. p
 Its origin in vegetables and animals. 74. p
 Procurable in large quantities from vegetables by coction. 22. p
 Of tartar *per deliquium*, whence called oil. 49. p
 That of human blood convertible into earth. 79. p
 Made from water. 185
 The heaviest part in vegetables. 90. p
 May be latent in acid bodies. 185, 186. p
 Of almonds, its virtues and uses. 73. p
 Of linseed, its virtues and uses. 73. p
 Of mustard-seed, its virtues. 73. p
 Of earth, what. 129
 The only fewel. 162. n. 263. & n. 30. p
 Whence it becomes such. 264
 Whence deemed a magnet, in respect of fire. 263
 Found in what forms in fewel. 263
 Its tenacity and branchy nature. 263, 264
 How affected, and at length consumed by fire. 264
 Whence differently inflammable. 264
 Of sulphur *per campnam*, why best made in a moist air. 253, 254, 287
 Its nature, virtues and uses. 254. p
 Resembles oil of vitriol. 254. p
 How made. 253, 254. p
 Of tartar, *per deliquium*, what. 155. p
 Of turpentine affected by cold. 248
 Turn'd to refin. 100. p
 How fitted for preserving anatomical preparations. 100. p
 Its effect, taken too freely. 102, 103. p
 Ætherial, whence called. 101. p
 Its virtues and uses. 102. p. 104. p
 How distill'd to advantage. 102. p
 Of vitriol, how made. 299. p
 Attractive of water. 306
 Volatilized by water. 323
 Why said to be fixed. 338
 Volatilizes fossil salts. 241. p
 Is a kind of fire. 241. 242. p
 Frozen. 224, 332
 Contains very little real acid. 338
 How dulcified. 262. p
 How made. 299. p
Oils, whereof they consist. 336, 80. p. 87. p
 Are a fluid camphire. 86. p
 Their kinds. 336, 337. 9. p
 Their analysis. 169, 183, 185, 186, 263. n. 264. n
 Of different nature. 185. n
 Convertible to earth and water. 183, 185. n
 309. & n. 327, 79. p. 82. p
 Not obtainable pure. 267, 337
 Their solutive power, whence. 336, 337, 351, 352
 Vegetable, what. 9. p. 69. p. 70. p. 78. p
 How made inflammable spirits. 66, 67. p
 Acid and impure. 336
 Whether the pure will dissolve metals. 336
 Whence they rust iron. 336
 How gained by expression. 336, 337
 Distilled, how gained and purged. 337
 The solvents of sulphurous matters. 331
 How separated from the other principles, and preserved. 99, 100. p
 How they lose of their force. 100. p
 Grow thick by age, heat, &c. 100. p
 How reduced into eleosacchara. 107. p
 Whether dissolvable in pure alcohol. 169, 170. p
 How rendered miscible with water by digestion. 170. p
 How convertible into spirits. 170. p
 How adulterated. 170. p
 The adulteration, how discovered. 170. p
 May become a kind of ice. 171. p
 Essential, what, and why so called. 78. p
 Contain the native spirit of the vegetables. 20. p
 Gain'd from the leaves of plants. 76, 77
 Where and in what forms found. 70. p
 Visible in the subject. 70. p
 How procured native by expression. 71, 72. p
 Their nature and uses. 72, 73. p
 Are apt to grow rancid and caustic. 72. & n. p
 With what caution to be prescribed. 72. p
 How obtained by emulsion. 73, 74. p
 Nature and use thereof. 74. p
 How changed milky. 74. p
 How advantageously procured by coction. 75, 76. p
 Their nature. 76. p
 Subjects proper to be distill'd for their essential oil. 76, 77. p
 To increase their quantity in distillation. 77, 78. p. 88. p
 Those of *Europe* float, but those of *Asia* and *America* sink in water. 78. p
 Their colours different. 78. p. 84, 85. p
 Whence unknown to the ancients. 79. p
 How purified. 79. p. 99. p
 Lose by rectification. 79. p
 Reducible to a waxy substance. 79. p
 Resolvable into four parts by water. 79. p
 Into what resolvable by distillation with addition. 79, 80. p
Oils,

I N D E X.

- Oils*, to separate their native spirit or soul from their gross matter. 80, 81. & n. p. 92. p
 Convertible to salt by time. 82. p
 Pre-exist in the subject. 82. p
 Their properties, medicinal uses, &c. 82. p.
 83. p. 84. p
 In what distempers proper. 83. p
 How distill'd from flowers *per vesicam*. 84. p.
 How distill'd from seeds and berries. 85. p
 To prevent their clogging the worm in distillation. 86. p
 How procured native from the *Indian* spices. 86, 87. p
 Are richest in the hottest countries. 87. p.
 93. p
 How known to be adulterated. 87. p
 How distill'd from barks. 88. p
 How distill'd from wood. 89, 90. p
 How distill'd native, *per descensum*. 92. p
 Their aromatic virtue, what, and wherein it consists. 92. p
 Why more aromatic than the expressed. 92, 93. p
 Animal convertible into earth. 221. p
 Their acrimony, whence. 221. p
 Are the same with those of vegetables. 221, 222. p
 222. p
 Terrestrial. 337
Oker, what, where found, how formed, &c. 138. & n
 138
 Contained in spaw waters. 138. n
 Its colours. 138. n
 Virtues and uses. 265. p
 Found magnetical. 93, 138. n
 Rich in iron. 123. n. 138. n
Oleum martis per deliquium, how made. 267, 268. p
 268. p
 Its virtues. 268. p
Opobalsamum, what. 159, 112. p
 Its substitute. 112. p
Operations in chemistry, what. 170, 173, 174, 188, 1. p. 2. p
 Reducible to two kinds. 174
 Their effects. 175
 Require the assistance of air. 303
 How varied by the air. 303, 304
 The caution requisite to render them successful. 304, 318
 Frequent reasons of their failure. 268, 303, 304, 314
 Scarce any performable without water. 306
 How variable by water. 314
 How varied by different degrees of fire. 378
Opium, its effects not like those of wine. 131. p
 Virtues of its extract. 168. p
 How purified. 220. p. 224, 225. p
 How made mild. 2
 To be cautiously used. 225. p
Ore of copper, where found richest. 90. & n
 How worked. 90. & n
 Of gold. 69. & n
 How work'd for the metal. 69. & n. 70, 71
 Of iron, what, and how treated. 94. n. 95. n
 Which the best. 94. n
 Of lead. 82. & n
 Poisonous to brutes and other animals. 82
 Of different kinds. 82. n
 Lead-ores class'd. 82. n
 Afford silver, but not in proportion to the lead. 82. n
 Of mercury. 76. & n
 Of tin, proving rich in silver. 97. & n
 How wrought. 98, 99. n
 Of silver. 85, 86. & n
 How wrought. 86, 87. & n
 How work'd in *Pernu* and *Chili*. 87. n
Ores, how treated by torrefaction, coction, amalgamation, lotion, fusion, distillation, and solution, for their metals. 70, 71
 How distinguished from marcasites. 132. n
 133. n
 How nearly the same with pyrites. 134. n
 Not always fusible without a particular management of fire. 268
 To try what metal they contain. 354
 How cleared of their sulphur, &c. 255. p.
 257. p. 258. p. 304. p. 306, 307. p
 Rationale of their purification by the flux. 305, 306. p
Orpiment, what, and where found. 126. & n
 Contains gold. 11. 126. n
 P.
Painting, what. 200
 Depends upon chemistry. 200. & n.
 201. & n
 In glass, what, and how perform'd. 201. & n.
 n. 202. n
 By whom restored. 201
 The colours for it, how made. 201. n
Pantaleo, a modern author in alchemy. 45
Parabolic-furnaces, their advantages. 381
Paracelsus, his history. 22, 30
 His education. 23
 Travels. 23, 24
 Made professor of physic and philosophy at *Basil*. 24
 Burns the books of *Galen* and *Avicenna*. 25
 Takes to drinking. 25
 Relinquishes his professorship. 25
 Manner of his death. 25
 Was an eunuch. 26
 His writings. 26, 27, 42, 364
 His real merits, what; and whence his great name. 28, 29
 D 2
 Para-

I N D E X

- Paracelsus*, knew the use and virtues of *Opium*. 28
 And of turpeth mineral. 29
 Had not the universal medicine, nor the philosopher's stone. 28, 30
 Peculiarities in his manner of writing. 364
 How he speaks of the *Alkabeft*. 363, 364
 His principal menstruum next the *Alkabeft*, what. 364
 Summary of his philosophy. 366, 367
 His greater and lesser sal circulatum. 371
Paraguay, the herb, its preservative virtue. 86. n
Pathology, what. 195
 How improv'd by chemistry. 195
Peat, what. 266
 Where found. 266
 Charr'd in *Holland*. 267
Peat-Mosses, how form'd. 266. & n
Pelican, what. 376
 Its use, &c. 376
 Its antiquity, and whence its name. 377
Perfumes, to recover their lost odour. 156. p
 To increase their virtues. 156. p
 How dissolved kindly. 174. p
Peripneumony, made mortal by *Chalybeats*. 265. p
Perpiration, insensible, the matter thereof in animals. 169
Petala, of Plants, what. 148
Petroleum, what, and where found. 129. & n
 Differs from *Naptha*. 129
Philalethes, a modern author in alchemy. 45
Philosopher's Stone, what. 42, 216
 The notion explained. 216, 217
 Antiquity of the notion. 8. n. 10, 12
 Unknown and unheard of among the ancients. 10, 11
 By whom first mentioned. 11
 Whether couch'd in the fables of the *Argonauts*, &c. 10, & n. 11, & n
 Its theory aid to be in the table of *Hermes*. 12. n
 The notion countenanced by *Hollandus*. 21
 Whether obtainable. 21, 44
 Whether known to *Paracelsus*. 29, 30
 Whether possess'd by *Helmont*. 216, 217
 Whether ever really discovered. 43. & n. 216, 217
 How far confirmed by testimony. 43, 44. n
 How far confirmed by reason and experience. 43, 44. n
 In what to be sought. 44
 Criterion of its Reality. 61, 62
 Its characters and effects. 216
 The same with metalline sulphur. 216
 To what metals always applied. 217
 Its multiplicative virtue. 217
 The most promising way to obtain it. 334
 Whether obtainable from lead. 276. p
- Philosophical Transactions*, the chemical pieces therein characteriz'd. 49
 Defect of *Lowthorp's* abridgment thereof. 49
Phlogm, what. 180. n
 Whether obtainable, pure. 180. & n.
 Of vitriol, its virtues. 180. n
 Whence obtainable, so largely from some bodies. 181. n
 See *water*.
Phosphori, what, and how made. 259. & n
 Various kinds thereof. 259. n. 250. n
 Their nature. 259. n. 275
 Whether they retain and imbibe fire. 259. n
 Of urine, and the manner of preparing it. 212, 259, 193. p. 196. p
 Manner of keeping it. 196. p
 Phenomena of it. 196, 197. p
 Solid, how made. 195, 196. p
 Fulminate in the dark. 260. n
 In vacuo. 269, & n. 270
 How prepared with safety and advantage. 330
 Obtainable from alkaline vegetables. 97. p
 Known to *R. Bacon*. 17
 To *Lully*. 18
 The danger in its preparation from blood. 37
Phthisis, a Remedy for it. 257. p
Physiology, what. 194
 How illustrated by chemistry. 194, 195
Pillula perpetua, what. 117, 306. p
Pissphaltum, what, and whence. 127. & n.
Pitch, what. 195. & n.
 How procured. 159. n. 160. n. 92. p
 Its kinds. 160. n.
Plague, a preservative against it. 146, 147. p
 An excellent medicine for it. 146, 147. p
 How affected by alkalies and acids. 178. p
 Whence. 282, 191, 192. p. 210. p
 How annually stopped at *Cairo*. 282
 Periodical, whence. 282
 Sometimes peculiar to certain species of animals. 282
Planets, whence denominated. 55. & n
 Their difference as to light, &c. 278. n
Plants, their origin. 143. & n.
 Their seed, what. 143. & n. 149. & n
 Their flowers, what. 149. n
 Their pistil, what, with the office thereof. 149. & n
 Their generation explained. 149. & n. 150. n
 Their apices, with their uses, &c. what. 149. n
 Their farina, with its office, what. 149. n
 Their stamina, what. 148, 149. n
 Their juices class'd. 150. 161
Plants,

I N D E X.

- Plants*, whether any part thereof be without iron. 155. n
 Whence perpendicular in their growth. 156. n. 157. n
 Their chyle, blood, &c. 160, 161. 166. n
 Succulent, how prepared for fermentation. 127. p
 See vegetables.
Pliny, his account of extracting gold from *Opiment*. 11
 Of making glass malleable. 12
Poisons, how rendered innocent. 179. p
 Their nature explained. 345
Polverine for glass, how made. 139. n
Pomatum, what. 110. n. p
Porcelain, how made. 316
 Of glass. 207
 Is mixed up with water. 316
Pot-Ashes, *Russia*, what, and how made. 45
Powers of nature, how far observed hitherto. 171. n. 192. n
Precipitate, white, how made. 290. p
 Its virtues and uses. 290, 291. & n. 292. p
 Green, how made. 291. p
 Red, how made. 291. p
 Its properties. 292. p
 Whether any precipitate of *mercury* may be used as snuff. 294. p
Precipitation, what, and how procured. 325, 326. p
 Its chemical doctrine. 325. p
 May be effected without a mixture of acids and alkalies. 326. p
 How effected by water. 323
Principles in chemistry, what. 75. n
 By whom first advanced. 22
 Producing. 175. n. 188. n
 Whether pre-existing in bodies. 175
 Their several offices in composition. 176. n. 177. n
 Active and passive. 172. n. 173. n. 177. n
 Intermediate, which. 177. n
 Not strictly elementary. 177. n. &c.
 See Element.
Processes, what. 12. p
 How delivered to best advantage. 2. p
Prognostics of Diseases, to be formed from chemistry. 195, 196
Projection, whether known to *Dee* and *Kelly*. 45, 46. n
 Its notion countenanced by its converse. 68. n
Pseudo-Diamond, its difference from the true Diamond. 115
Pulvis fulminans, its effect accounted for. 210. n
Putrefaction, its nature and uses. 176. p
 How cured or prevented in meats, &c. 213. 322
 Greatly favoured by the air of some places. 287. n
 Obtains not in *vacuo*. 300
 Whence caused. 300. n. 176. p
 Its requisites. 322
 Necessary to produce animal substances. 300. n
 Its difference from fermentation. 116. p. 176. p
 Its phenomena in vegetables. 175. p. 177. p
 How it converts vegetables into animal substances. 175. p. 177. p
 The medium of converting vegetable into animal substances, and *vice versa*. 176. p
 Not found in living bodies. 177. p
Putrid Diseases, their nature, whence, unknown to the antients. 195, 196
Pyrites, what. 134. & n. 261
 Its meaning settled. 134. n
Pyrotechnia, an appellation of chemistry. 9
- Q
- Quick-silver*, its chemical character explained. 56. 58
 Its nature, metalline. 58. 288. p. 297. p
 Nearly allied to gold. 58. 291. p
 Its specific gravity. 59. 72
 May, perhaps, be made heavier than gold. 72
 Its fluidity. 72
 Least malleable of all bodies. 72, 73
 Its great separability. 73
 Smoothness of its parts. 73
 Its particles used as a *camera obscura*. 73. n
 Its divisibility. 73
 Volatility. 73
 Recoverable from its fumes. 73
 How to fix it *per se*. 73
 Ill effects of its fumes. 73. 74. 77
 How they affect gold. 74
 With what metals disposed to unite. 70, 74
 Whether it will amalgamate with iron. 74. 77
 Best handled with iron instruments. 74
 Its use in gilding. 74
 In separating silver. 87. & n
 Cleaves only to metals. 74. 77
 Its disposition to receive heat and cold, as its gravity. 74. 75. 272. n. 274
 Contains fire. 227. n. 235
 Not congelable by cold. 74. n
 Dissolvable in acids, except vinegar. 75
 Convertible into different medicines. 75
 Its manner of acting in the body. 76
 Its medicinal virtues, whence. 76. 289. 290. p
 To know if it be adulterated. 75. 288. n. p
 Its simplicity, and whence esteemed a chemical principle. 75
 Of the philosophers, its purity. 75. 76. 77
 A compound body. 75. n
 Convertible into metal. 75. n
 Quick-

I N D E X.

- Quicksilver*, convertible into gold. 100. & n
 Void of acrimony. 76
 Where found, and in what forms. 76. & n
 Procured from vegetables. 76. n
 How separated from the ore. 77
 How cleared of arsenical matter. 77
 How cleared of earth. 77
 How it goes to the composition of metals. 100. n. 101. n
 What hinders its being gold. 102
 Its faculty of destroying worms in the body without loss of weight. 117
 Incalcescence with gold. 127. n
 How sublimed to a red powder. 376, 377
 How dissolved and crystalliz'd with *aqua-fortis*. 288. p
 How cleared of noxious parts. 288. n. p
 How made soluble in water. 288. p
 How it raises a salivation. 289. p. 295. p. 297. p
 Virtues and uses of its solution in *aqua-fortis*. 289. p
 Its solution giving a purple stain. 289. p
 Properties and uses of its vitriol. 289, 290. p
 How precipitated out of *aqua-fortis*. 290. p
 Its red precipitate or calx, how procured. 291. p
 How recoverable from its solution. 291. p
 Made more active by acids. 291. p
 How dissolved with oil of vitriol. 292. p
 Its solution in oil of vitriol poisonous. 292. p. 293. p
 Its fiery oil, how made. 293. p
 Whence called *Ignis Gehenna*. 293. p
 Its poisonous nature. 293. p
 Its fixation, how approximated. 293. p
 How made into *Æthiops*. 295. p
 How recovered from *Æthiops*. 295. p
 Its virtues when greatest. 296. p
 How recovered from cinnabar. 296. p
 How amalgamated with Lead, &c. 296. p. 297. p
 See *Mercury*.
Quintessence, what, according to *Ludovicus*. 82. p
Quintessences, liquid, how prepared. 169, 170. p
 Their virtues and uses. 170, 171. p
 Of *Asiatic* resins, how prepared. 171. p
 Of camphire, its virtues. 171. p
 Dry, how prepared. 172. p
 Their virtues and uses. 172, 173. p
 R.
Rain, how necessary to vegetation. 150. n
 Water, how obtainable in its purity. 310
 Its lixivious nature. 310
 Water, why best for malting and brewing. 123. p. 126, 127. p
Rarefaction, whence in solids and fluids. 222.
Realgal, what. 126. & n
Receiver chemical, what. 375
Recomposition, whether to be effected in chemistry. 175, 188
Refrigeratory, what. 380, 36. p
 Its use. 380, 36. p
Regulus of Antimony, how made. 305. p
Martialis stellatus, what, and how made. 306, 308.
 How near the nature of a metal. 308. p
 Properties and uses of its scoria. 306, 307, 308. p
 Its virtue not inexhaustible. 306. p
 How procurable in greatest purity. 319. p
Retort, what. 375
 The manner of its use. 375
 How coated. 382, 383
 How cut. 101. n. p
Rhodium, its oil, how gained to advantage. 89, 90. p
Rickets, how remedied. 162. p. 271. p. 302. p
Rigidity, what. 345
 Its power. 345
Ripley, George, his character, writings, opinions. 20
Rivers, whence. 311. & n
Robs, what and how made. 25, 26
 Their nature and uses. 27, 28. p
Roots of Plants, what. 144
 Their manner of growth. 150. n
 How fitted for fermentation. 127. p
Rosemary, its native spirit, or fragrant Water, how procurable. 12, 13. p
Roses, by their odour causing great disorders. 19. p
 Their oil how gained to advantage. 84. p
 Virtues thereof. 84. p
Rosin, what. 160. 9. p. 165. p
 Whence. 93. p
 How made. 101. p
 Its virtues and uses. 104. p. 166. p
 Wherein different from *Colophony*. 101. p. 104. p
 How gained from resinous tinctures. 165. p
 Prepared three ways. 165, 166. p
 Its colour, what. 165. p
 How distinguished from gums. 165. p
 Generally purgative. 166, 167. p
 How best exhibited. 166. p
 Its force, how abated in the body. 166. p
 In what constitutions unsafe. 166. p
 May act variously upon the body. 166. p
Rue, virtues of its oil. 83. p
Rust of a metal, what. 71. 302. 267. p. 276. p
Rust

I N D E X.

- Rust of a metal*, whence it proceeds. 288.
 289. n. 302
 How caused by the air. 288, 289. 302. & n
 How prevented in metalline utensils. 92. 336
- S.
- S** *Accharum Saturni*, how made. 276. p
 Its virtues and uses. 277. p
 No safe internal. 277. p
 A slow poison. 277. p
Saffron, its tincture, how best obtained. 160. p
 Virtues and uses thereof. 160, 161. p
 Contains a very subtil oil. 160. p
 Requires to be cautiously used. 160, 161. p
 Odd effects of too large a dose. 161. p
 Diffusive virtues of its extract. 168. p
Sal Ammoniac, ancient, its origin. 110. 199. p
 200. p
 Whence its name. 110
 Why called *Sal Cyrenaius*. 110. 199. p
 Whether native or factitious. 110, 111. n.
 199. p
 Its character. 110. 201. p
 The ancient, whether the same with ours. 110, 111. n
 Why no longer found as usual. 110
 Modern, whether native or factitious. 110,
 111
 Whereof it consists. 111. & n. 204. p
 Whence it comes. 111. & n. 199. p
 How made. 111. n. 198. 199. p
 Whether with or without sublimation. 111. n
 198, 199. p.
 Its power of volatilizing metals and mine-
 rals. 357. 201. p. 271. p
 Its kinds. 199. p. 200. p
 How purified. 200, 201. p
 Its virtues and uses. 200. p. 204. p
 Gives coldness to water. 200. p
 Is neither acid nor alkali. 200. p
 How purified by sublimation. 201. p
 Its nature betwixt volatile and fix'd. 201. p
 How distinguished from animal salts. 201. p
 204. p
 Unchangeable by sublimation. 201. p
 Whence called *Aquila alba*, &c. 201. p. 271. p
 Distill'd with quick-lime. 202. p
 Virtues and uses of its volatile spirit. 202. p
 With fix'd alkali. 202. 203. p
 Affords an exceedingly strong volatile and
 alkaline salt. 202, 203. p
 Reduced to a sea-salt. 203, 204. p
 Its extemporaneous production with spirit
 of salt. 250. p
 Whereof it consists. 250. p
Sal circulatum Paracelsi, what. 371
 Its strange effect. 184
- Sal Gem*, what. 106
 The finest where found. 106
 Mountains of it. 106
 Unknown to the antients. 106. n
 How dug in the mines in *Poland*. 106. n.
 107. n
 Ground to flower by the mill. 107. n
 Of two kinds. 107. n
 Found of various colours. 107. n
 Dissolved and crystalliz'd. 107
 Scarce differs from the sea salt. 107. 246. p
 Contains water largely. 316
 Its nature, virtues, and uses. 245, 246. p
 See *Sea Salt*.
- Sal Enixum Paracelsi*, what. 241. n. p
Sal mirabile, *Glauber's*, of nitre, how made. 244, 245. p
 Its odd nature, properties, and virtues. 245. p
Glauber's of Sea Salt, how made. 247, 248
 Its properties, virtues, and uses. 248. p
Sal Polychrestus, what, and how made. 118. p.
 238, 239. p
 Its nature, virtues, and uses. 239
 Its name, whence. 237. p
Sal Prunella, how made. 238. p
 Whence the name. 238. p
 Its virtues. 238. p
Sal volatile Oleosum, the *Simple*, how made. 266. p 2261
 Its original author. 22
 How varied. 326. p
 The compound, how prepared. 227. p
 The specific, how prepared. 227. p
 How to be varied. 227, 228. p
 Extemporaneous, how produced. 228. p
 Its virtues and uses. 228, 229. p
 In what cases properly used. 228, 229. p
Salivation, how raised by mercury. 289. p
 Its foetor, whence. 289
Salt, sea-salt, its excellence. 65, 66
 Where found. 105. 245. p
 Where and how made. 105. n. 106
 Is of two kinds. 105. n
 Its use to the ocean. 105
 Its rise, whence. 107
 The same with *Sal Gem*. 107
 Not alterable in the body. 193. p
 Its natural uses. 197. p. 200, 201. p. 246.
 Medicinal virtues. 194. p
 Whether a solvent for the Stone. 198. p
 How regenerated from *Sal Ammoniac*. 203.
 204. p. 249. p
 The only solvent of gold, except mercury. 246. p
Glauber's spirit thereof, how made. 246,
 247. p
 Its virtues and uses. 247. p
 Convertible to acid. 247. p
 Convertible to *Sal mirabile*. 247, 248. p
Salt,

I N D E X

- Salt*, animal, its nature and character. 169
 The principle, what. 176. n. 181.
 182. n.
 A vague one in the earth. 112. n.
 Elementary, what, and the notion thereof
 explained. 112. & n. 113. & n.
Bay Salt, whence its name. 105. n.
 How and when made. 105, 106. n.
Rock Salt, what. 106. & n. 107. & n.
 Has a metalline part. 134
White Salt, what. 105. n.
 Where and how made. 106. & n.
 How from *Bay Salt*. 106. n.
 Simple and unchangeable. 107
 How extracted from the salt springs of Eng-
 land. 107. n. 108. n.
 How purified. 245, 246. p.
 How decrepitated. 245. p.
 Neither acid nor alkali. 246. p.
 Its fixed and unchangeable nature. 246. p.
Salt Marsh, what. 105. n. 112. & n.
 113. & n.
 How made. 105. n.
Salt Mines, supplied with fresh water. 107. n.
Salt-Petre, affords an acid. 184
 See *Nitre*.
Salt Springs, how treated for salt. 107. n. 108. n.
Salt of Tartar, how made and procured to ad-
 vantage. 156. p.
 How made volatile. 179. p. 186. p.
 Turned to earth. 182
 How alterable by the air. 187, 188
 Volatile, from minerals. 288. n.
 Common, how volatiliz'd. 302, 304
 Fix'd, attractive of water. 306
 Turned to earth. 308, 327
 Made to give a red tincture with pure *alco-*
hol. 362
 Made into a waxy substance. 188. p.
 How procured, 155. p. 163. p.
Harvey's tincture thereof, how made. 162. p.
 Its virtues and uses. 162. p. 163. p.
Helmont's tincture thereof, how made. 163,
 164. p.
 Its nature. 164, 165. p.
 Requisites to the extracting its tincture. 163,
 164. p.
 Whether it will yield any tincture to *alcohol*.
 164, 165. p.
 Uses and virtues of it. 164, 165. p.
 Revivifying, what. 101
Salts, defined. 105. 182. n. 184
 Division thereof. 182. n.
Fossil, of two kinds. 105
 Simple, and compound. 113
 Native, which. 105. 109
 Perfect, which. 107
 How form'd in the earth. 112. & n. 113. & n.
 Their composition. 112. & n. 113. & n.
 182. & n. 183. n. 184
 Resolvable into acids and earth. 113. & n.
 Their figures, crystals, &c. 113. n. 182, 321
 Depend upon the alkaline matter mixed with
 them. 113. n.
 A principal characteristic thereof. 141
 How converted into one another. 250. p.
 Vegetable, infinite species thereof. 53. p.
 The acid, classed. 183. n.
 The *intermediate*, what. 183. n.
 Their manner of action, whence. 183. n.
 The *minous*, of three kinds. 183. n. 184. n.
 Producing and convertible into each other.
 184
 How volatiliz'd in animal bodies. 194,
 195.
 Best dissolved in the cold air. 299
 Sea-salt volatiliz'd. 329
 Contained in the air. 281. & n. 285. n. 286. n.
 Whether all are form'd of, and convertible
 into water. 308. & n. 316
 Different kinds at the same time disso-
 luble into water. 320
 Act not unless dissolved. 320, 323, 333, 334,
 335
 Are menstrooms. 334
 Compound, what, and which. 339, 340,
 341
 Their different names. 339, 340
 How transformable into one another. 340
 Artificial, superior to the natural, for medi-
 cinal and chemical uses. 340, 341
 Great improvements may be made there-
 with. 341
Essentiated, what, and why so called. 341
 Their knowledge of the utmost importance.
 341
 How many at once may be advantageously
 compounded. 341
 May increase in force by composition. 357
Essential, or native, how procurable. 34. p.
 Their species. 35, 36. p.
 Not simple bodies. 36. p.
 Into what resolvable. 36. p.
 Have the virtues of their plants, but in a
 greater degree. 36. p.
 How obtainable from plants. 43. p.
Nitrous of plants, which. 35. p.
 Impediments to their shooting. 35. p.
 Shoot in fermented juices. 36. p.
 Medicated, how prepared. 36, 37, p. 41. p. 52. p.
 Virtues thereof. 38. p. 40. p.
 May be used as sea-salt. 38, 39
 How and with what caution to be admini-
 stred. 40. p.
 Saponaceous, how obtained. 37, 38. p.
 Salts,

I N D E X.

Salts, how separated, purified, whitened, &c.

188 p. 235 p

May have their attractive, without affecting the dissolving liquor.

151, 152 p

How regenerated.

183, 186 p

English, what.

226, 227 p

Their property of fixing metals.

284 p

Their action in the body, how determin'd.

301 p

Alkaline and fiery with lime, how made.

50 p

Fixed, what, and whence.

183 n. 184.

52 p

How made volatile.

328, 329, 357

Not naturally contain'd in vegetables

31 p.

52 p. 250 p

Very different from the native.

55 p

How procur'd from vegetables.

42 p

How in greatest quantity.

37 P. 42, 43 P.

52, 53 p

How made for glafs.

139 n

Their matter originally volatile.

52, 53 p.

Are the production of fire.

52 p

Do not naturally præexist in the subject.

52,

Their difference, whence.

53 p

Corrosive, whence.

54 p

Violently corrosive, how made mild.

53 p.

Detain fire.

54 p

Their composition.

54 p

Are capable of crystallization.

54, 55 p

Animal, what and whence different from the vegetable.

55 p

Neither acid nor naturally alkaline.

189 p.

Their effects in the body.

190, 191 p

Their nature changeable, except that of sea-salt.

197 p

Whether they all proceed from acid and earth.

54 p

How affected by heat.

189, 190 p

May prove violently emetic without being alkaline.

191 p

Not naturally volatile in the body.

209 p

May be rendred volatile three ways.

195 p

Essential of the human body, what and how procur'd.

193 p

Their volatility.

218 p

How best preserv'd.

ib.

Universally the same.

219 p

When turn'd alkaline, or volatile, prove mortal.

209, 210 p

Mineral, how essentificated or impregnated with their own acids.

244 p. 249 p.

Recoverable from their acid spirits.

243,

244 p

How united with the vegetable salts.

265 p

Neutral, what and whence.

356, 243 p

Obtainable upon a mixture of acids and alkalis.

243, 244 p

Volatile, how purified.

330. 220 p. 222

All of the same nature.

223 p

But one in all nature.

ib.

Their difference, whence.

ib.

Their effects in the body.

223, 224 p

Are very exhalable.

223 p

Of less force than the fixed.

224 p

Their caustic virtue.

224 p. 229 p

May prove pernicious if imprudently smell'd at.

224 p. 229 p

Their affinity with the fixed.

224 p

How fix'd and made dry.

334, 340

Salzabrum of *Paracelsus*, what.

291 p

Sameck of *Paracelsus*, what and how made.

181, 182 p

Sand, how prepared for glafs.

139 n

For green and crystal glafs, whence obtained.

139 n

Showers thereof.

326

Sand-furnace, what.

380

Its use.

ib.

Sandaracha Gracorum, what.

126

Sandiver, what.

140

Sands, what.

122, 325

Of two kinds.

112 & n

The proper very durable, and not calcinable.

122 n

Their figure constant.

ib.

Of *England*; class'd.

ib.

Their office in nature.

124

Saps, their nature and composition.

152, 153

How procurable to advantage.

151 n. 152 n

Their kinds.

150, 161

Sap of the vine, its uses.

152 & n

Sapas, what and how made.

25, 26 p

What the word agniently signified.

25 p.

& n

Sassafras, how best treated by decoction.

23 p

Savin-water, its virtues.

64 p

Virtues of its oil.

83 p

Scammony, its tincture, how best extracted.

159 p

Scarlet dye, what and by whom invented.

203

Its permanency.

203

Why best struck at *Leyden*.

289, 314

Schirrosities, what, and their cure.

186, 187 p. 207 p

Scurvy, how cured in cold countries and constitutions.

192 p

Medicine for it.

162 p. 163 p. 168 p. 247 p

Sea, its saltness, whence.

307 n

Sea-jelly described.

165 n

Sea-nettle described.

ib.

Its progressive motion.

ib.

Sea-plants, how produced.

143 & n

See *Vegetables*.

Sealed Earths, their number.

124

Seasons, what, and how brought about.

284

Their difference, whence.

278 n. 286 n

E Seed,

I N D E X.

- Seed*, the notion thereof explained. 120
 Whether stones arise therefrom. 119, 120
 Its structure in vegetables. 155, 85 p
 Use of its essential oil. 158, 85, 86 p
Seeds, mealy, what. 118 p
 How malted, or prepared for fermentation. 123, 124 p
Semeiotics, what. 196
Semi-metals defined. 196, 131, 132
 Whether convertible into metals. 131
 Classified. 131, 132
 Those consisting of metal and sulphur, 132, 134
 metal and salt. 134, 136
 metal and earth. 136, 138
 Are menstruums. 334
 Are of two kinds. 298 p
Seminal Impressions, whether any exist. 54 p
 Virtues, how conceived of by *Helmont*. 368
Sena, its purgative virtue, how best extracted. 159 p
Serum of the blood, what. 210 p
 Is neither acid nor alkali. 210, 211 p
 Its nature, how known. *ib.*
 How affected by acids and alkalies. *ib.*
 Putrefied by digestion. 211 p
 Concreted with heat. 212 p
 Its affinity to the white of eggs. 213 p
 216 p
 Coagulable with alcohol. 213 p
 How preservable uncorrupted. 213 p
 Distill'd with a gentle heat. 214, 215 p
 The water distill'd from it neither acid nor alkaline. 214 p
 Affords a copious water by distillation. *ib.*
 Naturally yields no volatile salt. 215 p
 Whether capable of affording an ardent spirit. 214 p
 Distilled with a strong heat. 215 p
 Its analysis. 215, 216 p
 The cautions requisite in its analysis. 215, 216 p
 How affected by fixed alkali. 230 p
 spirit of fal ammoniac and
 volatile alkalies. 230 p
 Its specific gravity. 230, & n. p
 How affected by the spirit of vitriol, of
 sea-salt, of nitre, and of vinegar. 231 p
 By *Glauber's*.
 By fal volatile. 231 p
 By tartarized spirit of wine. 231 p
Shell-fish, their progressive motion. 164 n
 Nourish their shells. 165 & n
Shells of snails, their formation and increase. 165 n
 Their structure. 165 & n
 How generated. 165 & n. 166 n
 Of mussels, how form'd. 166 n
 Of lobsters, &c. whence. 167 n
Sideroxylys, its use to the *Indians*. 249
Sieve of Vulcan, what. 326
Signs in Medicine, what. 196
 The doctrine not well known by the an-
 tients. 196, 197
 known from chemistry. 196
Silk-worm, its number of hearts. 163
Silver, its chemical character explain'd. 56, 57
 Convertible into gold, and how. 44 n. 57,
 83, 85, 101 n. 102, 215
 Its specific gravity. 59, 83
 Gained from lead. 81
 from Tin. 97 & n
 Whether from antimony. 131
 Its fixedness. 83
 Rendred volatile. 83 n
 By antimony. 85
 Exposed to a burning-glass. 83 n
 Vitrify'd. *ib.*
 Long kept in fusion. 83 n
 Strictly unites with tin. 83, 96, 97 n
 Its ductility, malleability. 83, 84
 Its fusibility. 84, 268
 How dissolved. 348. 279, 280 p
 Its menstruums. 80. 84 & n
 Soluble in a particular *aqua regia*. 84
 Uses of its solution. 280 p
 How separated from gold. 85 n. 86, 87 & n
 Apt to be lost in separation. 86
 Resists lead in fusion. 85
 Has most of the properties of gold. 102
 Wherein it remarkably differs from gold. 85,
 101 & n
 Its found. 85
 In what forms found. 85 & n. 86
 In gold ore. 85 n. 86 n
 Contain'd in gold. *ib.*
 In lead ore. 82
 In copper ore. 86 & n
 Its mines dangerous to work. 86 n
 Its sulphur antimonial. 86
 Difficult to procure on account of the ad-
 hering sulphur. 86
 To find how much is contain'd in any
 matter. 87
 How obtain'd in *Peru* and *Chili*. 87, 88 n
 Counterfeited with copper and arsenic. 126 n
 Pure, how fitted for use. 209
 Its calx changed by fixed alkali. 350, 351
 Its vitriol or crystal how obtain'd pure. 280 p
 Nature and use thereof. 280, 281 p
 To discover gold therein. 280 p
 Its purging vitriol how made. 282 p
 How made *Luna Cornea*. 283 p
 Acquires a new nature in *Luna Cornea*. 283,
 284 p
 Reduced to metal again from its inflamma-
 ble vitriol. 284 p
 Simpli-

I N D E X.

- Simplicity*, its notion explain'd. 67
- Skeletons*, how whiten'd. 350, 31 p. 46 p
- Skin*, certain disorders thereof, how remedied. 106 p
- How made black. 280, 290, 291
- Small-pox, confluent*, how treated by *Sydenham*. 197, 198
- Smalt*, what and how made. 134 p
- Smoke*, what. 271, 29 p. 96 p
- Of fewels different. 268
- Some poisonous. 266, 268
- The measure of fire. 271
- Its nature and phenomena in burning fewel. 271
- Two kinds thereof. 29 p
- Why offensive to the eyes and lungs. 96 p
- Snails* described. 166 n
- Whence furnish'd with shells. 165 n
- Peraspire. *ib.*
- How their shells grow. 166 n
- Snow*, whence it lies upon high mountains. 244
- Soap*, its analysis. 175 n. 176 n
- Remedies and menstruums to be reduced to that form. 357
- Of two kinds, an acid and an alkaline. 95 p
- Of sulphur, how made. 260 p
- Its nature and uses. 260, 261 p
- The different kinds, how made. 175, 176 p
- Portable, how made. 28 n. p
- How prepared with oils and fixed alkali. 176, 177 p
- When made most perfect. *ib.*
- Its medicinal virtues and uses. 177 p
- How best exhibited. *ib.*
- An almost universal medicine. 177, 178 p
- Of philosophers, what and how made. 178, 179 p
- Of *Starkey*, what. 179 p
- Why call'd *Matthews's* corrector. 179 p
- Its virtues and uses. 180 p
- How united with alcohol. 180 p
- The finest, which. 165 p
- Soda*, what. 339, 45 p
- Soils*, their difference as to heat and cold. 244
- Solidity*, superior in bodies, whence. 237
- Whereon it depends. 254, 345
- Its criterion. 345
- See *Fire and Light*.
- Solids*, may have an intestine motion. 223
- Not very different from fluids. *ib.*
- Contain water largely. 306
- May be made of the most fluid and volatile bodies. 226
- Solution, chemical*, how and in what manner perform'd. 310 n. 324 p
- Two kinds thereof. 301
- Variouly effected by different bodies. 344, 345, 346, 347
- Solution*, when most perfect. 347
- What. 265, 29, 30 p. 96 p
- Soot*, its analysis. 179 n. 184, 288 n. 96 p
- Whence combustible. 30 p. 96 p
- Sound of Copper*, increased by tin. 98 & n
- Sounds* alter'd by the weather. 287
- Spagyric Art*, what and whence so called. 9
- Spar*, what. 99 n
- Spaw-water*, how imitated. 264, 265 p
- Spirit, native*, of vegetables, what and where seated. 12 p. 18 p
- Its great efficacy. 18 p. 20 p
- Of *nitre*, how made proof. 280 p
- Whether made by unsheathing the acid from the salt. 340
- Spiritus nitri dulcis*, how made. 242, & n
- Its nature, virtues and uses. 242, 243 p
- Which the best. 239, 241 p
- See *Nitre*.
- Of *salt*, its great uses in life. 213
- Spirit of Wine*, if a sulphur. 125
- Why miscible with water. 125, & n
- Whether and how convertible into water. 281, 308 n
- Its compound nature. 181, & n
- Obtainable the same from all vegetables. 213, 214
- Whence incapable of freezing. 224
- How affected by cold. 248
- Recoverable after it is burnt. 262
- Only burns in its surface. 273
- In some cases preferable to alcohol. 362
- Spirits*, whether convertible into water. 309, & n
- Alkaline* defined. 337
- Their analysis. 337
- Gained from animals, what. 221 p
- Whence procured. 337
- Alkaline coagulable with alcohol. 225 p
- Acid* defined. 338
- Of what they consist. 338
- Whence procured. 338, 185 p
- Divided into volatile and fixed. 338
- Whether naturally contained in alkaline salts. 340
- Reducible to three. 354
- Simple, medicated, aromatic, what and how prepared. 173 p
- Their virtues and uses. 173, 174 p
- Compound, medicated, aromatic, how prepared. 174, 175 p
- Chemical what. 168, 181, & n. 337, 338, 339 p
- Producible. 181 n. 221 p
- Vinous*, alkaline and acid, of a compound nature. 181 n
- Inflammable* and un inflammable. 337, 338
- Inflammable, what and whence obtained. 338, 339, 69 p
- How procured. 132, 135 p

I N D E X

- Spirits*, how gained to advantage from metalline subjects. 133, 134. p
 Their nature, virtues and uses. 134, 135. p
 207, 208
 How rectified or made proof. 136. p
Rectified, whether acid or alkaline. 136. p
Unrectified, of what they consist. 136
 How made undistinguishable from alcohol of wine. 136, 137. p
 How made into alcohol. 137. p. 140. p
 Two ways of purifying them. 137. p
 Not easily cleansed. 137, 138. p. 140, 141. p
 When proper menstruums. 159, 160. p
 Whence poisonous. 207, 208, p. 213. p
Springs, whence. 311. & n
Starkey's Pills, what. 179. p
Stars, what according to *Newton*. 240. n
Steel, what and how made. 91, 92. n. 248.
Stones defined. 114
 Of what they consist. 316
 Wherein they differ from metals and other minerals. 114
 Divided into Classes. 114. & n. 115. & n
 Precious which. 114. & n
 How generated. 195, 196. p. 198. p
 Its matter wherein residing. 108. p
 How prevented. 198. p
 Whether its menstruum be contained in urine. 196. p. 198. p
 Whether caused by iron. 94
 Medicines for it. 102. p. 109. p. 118, 119. p
 182. p. 242. p
 Classed. 114. & n. 115. & n. 118. n
 Their origin and formation. 118. n. 119.
 120, 121.
 Were once fluid. 116. n. 117
 How form'd by nature. 115
 Counterfeited. 116
 Vulgar, their nature. 118
 Their analysis. 118. n
 How convertible into glass. 118
 Classed. 118. n
 Their origin and formation. 118. n
 119, 120, 121
 Whether they grow in the quarry. 118. n
 Whether organiz'd. 118, 119
 Whether they rise from seed. 119
 Were once fluid. 119, 120
 Growing like plants. 118. n. 119
 All their basis, earth. 120
 Specific gravity, &c.
 Their criterion. 123. n. 59
 Engraven how finely copied on glass. 207. n.
 208. n
 How affected by the air. 302. & n
Human, its menstruum. 352, 361. 196. p
 198. p
Stim, what. 129. p
 How preserved. 129. p
- Stupefaction*, from *Opium*, or otherwise, a remedy for it. 146. p
Styptick, 103. p. 139. p. 267. p. 277. p
Sublimate Corrosive, how made. 295. n. p
 How remedied as a poison. 301. p
 Its nature and uses. 245. n. p
Sublimation, what. 175. n
Succory, its distilled water whether vermifugous. 60. p
Sudorific, an innocent and powerful one. 146. p
Sudorifics, what and how they act. 39. p
Sugar breeding maggots. 287. n
 What. 359
 Its uses. 359
 Considered as a menstruum. 359
 Whether prejudicial to the body. 107, 108. p
 What. 107, 108. p
 Its medicinal virtues. 108. p
 Its nature hard to settle. 108. p
Sulphur, fossil defined. 125, 251. p
 Species thereof. 125
 Solid, which. 125, 263
 Liquid, which. 128, 129, 264
 Its analysis. 125, 129. & n. 130. & n. 253. p
 Acid thereof. 112, 253, 254. p
 Whence difficult to analyse. 129. n. 179. n
 Recomposed. 130. n. 261. p
 How formed in the earth. 112. & n. 113. & n. 254. p. 261. p
 Its flame what. 125
 Its fume dissolves metals. 125, 126. n
 Yellow, what. 125, 251. p
 How known when good and pure. 125, 126
 Supposed antidotal. 125, 252. p. 255. p
 Common, whence obtained. 125. & n
 Its great Inflammability. 126. & n
 Mistakenly applied to make the Philosophers stone. 126
 Vivum, what, and where found. 125
 How discoverable in fine regulus of antimony. 131
 External and *internal* in metals. 132, 139
 Makes metals brittle. 63, 91, 126, 131, 132
 Volatilizes metals. 64
 Whence known to abound in iron. 91
 Not touched by acids. 97
 Hinders quick-silver from being gold. 102
 A common menstruum to metals. 333, 334
 Is an ingredient in metals. 251. p
 Its properties and characteristics. 251. p
 Neither acid nor alkali. 251. p
 Allied to rosin. 165, 166. p. 251. p
 Whether it may be made metalline. 251. & n. p. 262. p
 How sublimed, purified or turned to flowers. 252. p
 Which best, the native or purified. 252. p
 Whereof it consists. 254. p
 Its use in fermentation. 129. & n. p. 254. p
 Its fume, how it becomes poisonous. 254. p
 Sulphur

I N D E X

- Sulphur*, how dissolved in fixed alkali. 254, 255. p
 Its oil per deliquium, how made. 254. p
 How rendred soluble in water. 255. p. 257. p
 Its tincture resembling that of gold. 225. p
 257. p
 How discoverable in ores. 255. p. 257. p
 How dissolved in volatile alkalies. 255. p
 Its virtues and uses, when dissolved by alkalies. 255. p
 How it acts in the body. 255. p
 Its tincture with alcohol, how made. 256. p
 How made into a syrup. 257. p
 How turned into balsams. 258. p. 260. p
 How dissolved in expressed oils. 258. p
 How dissolved in distilled oils. 258, 259. p
 With what oils it dissolves the best. 259. p
 How dissolved in alcohol. 260. p
 Virtues of its solution in alcohol. 260. p
 Its soap, how made. 260. p
 No extraordinary internal remedy. 260. p
 How generated from oil of turpentine and oil of vitriol. 261. p
 How generated from oil of vitriol and alcohol. 262. p
 Its magistery, how made. 262, 263. p
 How precipitated in solutions. 263. p
 May lie latent in fossils. 304. p
 Of metals, what. 100
 Esteemed an universal medicine in some cases. 103, 104
 Taken for the grand elixir. 104
 The principle, what; its nature, genesis, &c. 176. n. 178. n. 185. n. 186. n
 Made by art. 180. n. 353, 354. p.
 Whence in metals. 185. n
 Obtained from cinnabar. 185. n
 Procurable from various matters. 185. n
 By what absorbed from metals. 208, 209, 255. p
 Conceiving heat, &c. with iron filings. 211, 212. n. 260. 322. n. 176. n. 178. n. 328. p
 The same with the matter of light. 16, 45, 64. n. 100. & n. 101. n. 177. n. 263. n. 264. n
Fixing, what. 102, 103, 139
 The only active principle. 141. 147. n. 186 n. 263. n. 264. n
Sun, its nature. 240. & n. 241. & n
 According to *Lemery*. 238. n
 What according to *Newton*. 240. n
 Its manner of acting upon terrestrial bodies. 238. n
 Does not emit, but collects fire. 238
 How supplied by torches, &c. 238, 239
 Whence his warmth. 239. 242
 Heat how occasioned thereby. 279
 Why not exhausted. 240. & n. 241. & n
 Compared to a mirror. 241
 Its action in vague fire explained. 241, 242
 Why incapable of thawing ice in *Nova Zembla*. 242. & n
 Its force, when greatest. 245
 Being pale and obscure for a year, its effects. 249. n
 Its chemical effect on the earth. 284
 Effects of its summers heat upon the vegetable kingdom. 12. p. 15. p. 18, 19. p
 A subterraneous one, whence. 237
Sweat, as a sign to be judged of from chemistry. 197
Sydenham, ill effects of his unacquaintance with chemistry. 197, 198.
Sylvius's febrifuge salt, what. 203, 204. p

T.

T *Achenius (Otto)* his character. 48
 His method of making medicated salt. 36, 37 p. 41 p
Tansy water, its virtue. 65 p
Tarso, what. 139 n
Tartar, what. 35, 36 p. 131 p. 141 p. 152, 153 p
 Its origin and production. 152 p
 By what wines afforded in greatest plenty. 35, 36 p
 How form'd in the vessel. 36 p. 130 p. 141 p
 Whence its name. 153 p
 Whence its acid taste. 297
 Which the best. 36 p.
 Is of the same colour with the wine. 36 p.
 Into what resolvable. 131 p
 The effect of fermentation. 16.
 Not volatile in water. 141 p. 153 p
 To increase its quantity in the cask. 152 p
 How made to serve as a vessel. 16.
 Difficult of solution in wine and water. 153 p
 182 p
 How conceiv'd of by *Paracelsus*. 153 p
 How resolv'd. 154, 155 p
 Its water, spirit, oil, and fix'd alkali. 154, 155 p
 Its penetrating nature in distillation. 155 p.
 Uses of its distill'd oil. 156 p
 Soluble or tartariz'd, how prepar'd. 181, 182 p
 Its virtues and uses. 182, 183 p
 An excellent menstruum. 183 p
 Its tincture, how made. 188 p
 How made readily dissolvable in water. 182 p
Regenerated, or terra foliata tartari, how prepared. 183, 184 p
 How made into a tincture. 161 p
 Its virtues and uses. 161 p
 A cheap substitute for it. 161 p
 How calcined. 163, 164 p
Tartarum Vitriolatum, how made. 300, 301 p
 Its virtues and uses. 300, 301 p.
Tastes,

I N D E X.

- Tastes*, how affected and alter'd by cold, want
of air, and great heights. 279,
299
Producible from insipid bodies. 23 p
The chemical doctrine thereof. 329, 330 p
Tears of Trees, how best procurable. 151 n. 152
What. 9 p
Teeth, how best whiten'd. 349, 350
Whence set on edge by acids. 350
Tendons shrunk, how remedied. 103 p
Terra foliata Tartari, how prepared. 183,
184 p
Whence the name. 184 p
Why call'd philosophical earth. *ib.*
Whence it yields a copious oil. 185 p
Whether volatile or fix'd. 187 p
Therapeutics, what. 197
Derived from chemistry. 197, 198
Thermometer, how first constructed. 293
Thunder, whence. 245, 246, 285
Effects of the air. 285
See *Lightning*.
Tin, its chemical character explain'd. 56, 57
Its nature. 57
Nearly ally'd to silver. 57, 96, 97
Its specific gravity. 58, 59, 96
Which the best. 96
Its softness and ductility. 96
Its great volatility. 96, 103
Its fusibility. 96
Its effluvia poisonous. 96
Its calx volatile, yet reducible. 96 & n
Its miscibility with other metals. 96, 97
Some parcels approach to silver more than
others. 97 & n. 98
Its difference from lead. 97 n
Of difficult solution in acids, unless calcined.
97, 98
Its medicinal virtues. 98
How to be calcined. 98
A specific for the epilepsy and hysteric fits.
98
Its elasticity and sound. 98
Where found. 98
Gave the name to *Britain*. 98
Its ore, how wrought. 98, 99 n
How separated. 98 n. 99 n
How clear'd of its sulphur, and made sil-
ver. 208
How mix'd with lead. 336
How calcined, dissolved, and crystallized.
285 p
How purified. 285 n. p
Tinctures, how made from resinous vegetables.
157 p
Which to be made with spirit, which with
alcohol *per se*, and which with alcohol
and fixed alkali. 156, 161 p
Which ought not to be filtr'd. 157 p
Their red colour, whence. 158 & n. p
When best drawn with low spirit. 158,
159 p
Of vegetables, what they contain. 160 p
How prepared with alcohol *per se*. 160 p
How prepared from hard bodies with alco-
hol and fixed alkali. 161, 162 p
Of hard resinous bodies, their general uses.
162 p
Resinous, how commodiously exhibited.
164 p
How precipitated into rosin. 165 p
From metals, what. 256, 257 p
Sulphurous, their virtues and uses. 256 p
Tarriying of ore, explain'd. 79
Tower-furnace. See *Ashanor*.
Transmutation of metals, whether at all real.
43, 44 n
Shewn to be possible. 103, 215, 216, 217
Directions how to proceed therein. 102,
104, 216
Trees, their manner of growth inquir'd into.
145 n. 148 n
Their bleeding. 151 & n
How best tapp'd for their liquor. 151 n.
152 n
Effects of their effluvia. 18, 19 p
How defended in cold seasons and climates.
7 p. 71 p
When said to grow old. 71 p
When best fitted for timber. 9 p. 71 p. 91 p
Their tears, whence. 93
Tripoli, its uses. 207 n. 208 n
Trituration, its force in effecting solutions. 335,
342
Its great effects in chemistry. 335 & n
Of three kinds. 342
Tubal Cain, the same with *Vulcan*. 6
Turf, its kinds. 266
The *Dutch*, its peculiarities. 266
Turpentine, whether it will dissolve copper. 336
Consider'd as a menstruum. 358
Its analysis. 101 p
Turpethum Minerale, how made. 294 p
Whence the name. *ib.*
Its nature, virtues and uses. *ib.*
Tyles, how made. 316

V.

- V**acuum, the most perfect, how made.
226
Valentine (Basil) his history, writings, opinions
and discoveries. 21, 22
First apply'd chemistry to medicine. 22
Valetudinarians, an excellent remedy for them.
41 p
Vapours, what. 280
Varnishes, how best made. 351
Vege-

I N D E X.

- Vegetables*, what. 53, 142
 Their distinguishing character. 153
 How fed by the earth. 124
 Their nourishment, what. 144 & n. 145, 7 p
 Distinguish'd from fossils and animals. 142
 How nearly analogous to animals. 142 n.
 149 n
 Their wounds to be treated as those of
 animals. 142 n. 10 p
 Whether they always grow from the earth.
 143 & n
 Situation of their roots indifferent. 143 & n
 May grow downwards. 143 & n
 Whence they grow upwards. 156 n. 157 n.
 Their vascular structure proved. 143 n
 Matter of their vessels indestructible. 143,
 144
 Their absorbing vessels. 144, 7 p
 Office of their roots. 16.
 Their sap, of what composed. 147
 How raised. 144 n. 145 & n. 146 & n. 7 p
 Progress and preparation thereof. 148, 149
 Throw off the recrementitious part. 144,
 145, 153 n
 Have a kind of respiration. 144, 8 p. 18,
 19 p
 Have their atmosphere. 11, 12, 13 p. 18, 19 p
 Consist of circulating vessels and air vessels.
 144, 7 p
 Circulation if at all, whence effected in them.
 144, 145 & n. 7, 8 p.
 Whether they are fed by the bark, wood
 or pitch. 146 n. 148 n
 To retard their blossoming and bearing.
 146 n
 Their manner of growth inquired into.
 145 n. 148 n. 7 p
 Their manner of generation explain'd. 149 n.
 150 n
 The growth of their roots. 150 n
 Their leaves, what. 148, 153
 Office and importance thereof. 148, 154
 Juices thereof. 159
 Various kinds thereof. 160. 8, 9,
 10 p
 Their chyle, how elaborated. 152, 160, 161
 Their fruit, what. 155
 Their seed, what. 16.
 Its manner of growth. 155, 158
 Their bark, what. 158
 Uses thereof. 158, 159
 Their digestion, how perform'd. 161
 Their blood, or peculiar juices. 161, 8 p.
 How distinguishable by chemical analysis.
 161 & n
 Their popular division. 161 n. 162
 How classed by botanists. 162
 Chemical division into acid and alkaline.
 98 p
- Their peculiar virtues, whence. 187
 Into what parts resolvable. 187 & n. 188 n
 May contain minerals and metals. 286 n
 Productive of quicksilver. 76 n
 lead. 82
 Their growth from water. 307 n
 Have valves in their vessels. 7, 8 p
 Their receptacles. 8 p
 Their scent and taste, whence. 11, 12, 13 p.
 16, 17, 18 p. 59, 60, 61 p. 69, 70 p. 82 p.
 92, 93 p
 Their native spirit small in quantity. 18 p.
 80, 81 p
 what and where lodged.
 18 p. 20 p. 80 p. 92, 93 p
 The vapour or water they spontaneously ex-
 hale in the summer. 12, 13 p
 Their native spirits or fragrant waters, how
 procurable to advantage. 154, 187 n. p.
 12, 13 p. 16, 17, 18 p
 How affected by the summer's sun. 12, 13,
 14, 15 p. 17, 18 p
 Their analysis, how to be conducted. 12 p.
 14 p
 A catalogue of those fittest to afford simple
 waters. 15 p
 The *aromatic*, which. 15 p. 92, 93 p
 Whether the tasteless and inodorous may be
 medicinal. 15, 16 p
 Composition of their aromatic simple wa-
 ters. 16 p
 Their specific virtues, whence. 16 p. 18 p.
 27, 28 p. 31 p. 33 p. 82 p
 When and how best gather'd for use. 17 p
 What they lose by exsiccation. 18, 19 p.
 31 p. 93 p
 What they part with in distillation. 18 p
 Their effluvia, what. 18, 19 p. 80, 81 p. 93 p
 Reducible to oil by coction. 22 p. 33 p
 The utmost effect of boiling water thereon.
 22, 23, p. 33 p
 The tenderest whence undestroy'd by the
 sun, rain, &c. 22, 23 p. 31 p
 How reducible to white insipid ashes. 29 p
 saline ashes. 32 p
 Of what parts they consist after decoction.
 30 p. 33 p
 How affected by long keeping. 31 p
 Naturally contain no fixed salt. 31 p. 33,
 34 p
 The more volatile, the less they yield of
 fixed salt. 32 p
 Their salt and oil how united. 33 p
 Their salts how naturally existing therein.
 33, 34, 35 p
 Their native or essential salts, how procur'd.
 34 p
 Their several species of salts. 35, 36 p

Vege-

I N D E X.

- Vegetables*, when they abound in salt, and when
in oil. 37 p. 71 p
How made to afford a large quantity of salt. 37 p
Their decoctions, what. 59 p
The vapour of their decoctions, what. 59, 60 p
The scent of their oil. 70 p
When said to sleep. 70, 71 p
Their Essence, what. 80 p. 92, 93 p
Wherein the hot differ from the cold. 93 p
The sun's action upon the aromatic tribe. 93 p
Method of resolving them. 94, 95 p
Their acid spirit reducible to water. 94 p
whence red. 94, 95 p
In what manner they contain oil and acid. 95 p
The virtues of their acid spirits, what and
whence. 95 p
Their acid small in quantity. *ib.*
Two kinds of oil therein. 182 p
Their native oils, how cleansed. 94, 95 p
Their empyreumatical oils, how cleansed. 95 p
The seats of their oil, water, and spirit. 96 p
Alkaline, how analysed. 97, 98 p
Approach the nature of animal subjects. 97, 98 p
Afford alkaline salt without putrefaction. 97, 98 p
Their oils and salts how purified. 97 p
Their parts gained by analysis not at all
miscible again. 103 p
Afford no inflammable spirit without fer-
mentation. 113, 114 p. 116 p. 126 p
Classed with regard to fermentation. 117, 132 p
The requisites to their fermentation. 120 p. 122 p
To be treated as malt for brewing. 123 p. 132 p
How fitted for brewing. 120 p. 127, 128 p
The general method of committing them
to fermentation. 128 p
By putrefaction made animal. 175 p. 177 p
Putrefied, how analysed. 175 p
All subject to putrefaction. 175, 176 p
Reducible by putrefaction to the same com-
mon nature. 176 p
Vegetation explain'd. 155, 156 & n. 157 & n. 158. 284
Why it succeeds not in *vacuo*. 299
Chemical, what. 244, 245 p
Visible instances thereof. 245 p
Venercal Disease, its rise. 24
How cured by *Carpus*. 24
How by *Paracelsus*. 24, 294 p
Best cured by acids. 91 p. 102 p. 294 p
Not caused by an acid. 98
Medicines for it. 102, 103 p. 163 p. 294 p
Venery, the appetite, how destroy'd. 277 p
Verdigrease, what. 88, 89
Its fine emetic quality. 89
Distilled, what. 151 p. 286 p
A pigment. 151 p
A strong attractive of the acid of vinegar. 151 p
Alters not the nature of vinegar. 151 p
Whence its loss of colour. 286 p
Its virtues and uses. *ib.*
Vermillion for painting, how prepared. 28 n
Vesien, what. 56 p
Vessels, chemical, what. 372
Their kinds. 372, 373
Metalline, their inconveniences. 372
When used. *ib.*
Of what best made. 372
Earthen, when to be chose. 373
Which the best. 373
Of Glass, their excellence and uses. 373
How chose. 373
Their imperfection. 373
Their figure to vary as their uses. 373, 374
Reasons of the diversity of their figure. 374, 375
Reducible to two kinds. 373, 374
Those for a close fire, of two kinds. 374
The knowledge thereof, whereon it de-
pends. 374
The principal and most useful, what. 375, 377
Their manner of application and use, whence
deriv'd. 377
Vinegar, what and whence. 117 p. 141 p
Its origin and production. 142 p
How made in *France*. 142, 143 p
Its subjects. 142 p
An artificial thing. 142, 143 p
Differs from native acids. 142 p
Best made from generous wines. 143, 144, 145 p. 147 p
Is not corrupted wine. 143 p
Deposits a saponaceous matter in the ma-
king. 143 p
Its rape, how to be cleansed. 143, 144 p
The better for use. 144 p
Its containing vessels the better for use. 144 p
May be advantageously prepared from malt
liquors. 144 p
How improved by spice. 144 p
Its nature, properties, medicinal virtues and
uses. 144 p. 146 p
Its virtues, whence. 148 p

Vinegar,

I N D E X

- Vinegar*, contains an inflammable spirit. 145 p
the tartar of the wine. 145 p
a fluid tartar. 145 p
How made into a dry salt. 334
Its power as a menstruum. 349, 355.
Exceeds that of wine. 155 p
Recoverable from its acid salt. 362
How procurable from balsams. 101, 102
Of balsams and balsamic woods, its virtue. 102 p
What it affords in distillation, and in what order. 145 p
Whether it yield an ardent spirit by distillation. 145, 146 p. 148 p. 150 p
Liquifies the animal juices. 146 p
How analyz'd or distill'd. 147, 148 p. 362
Virtues and uses of its spirit. 149 p
Its spirit a great antidote. 149 p
Uses of its rectified spirit. 150 p
Distill'd, how rectified. 149, 150 p
Affected differently from wine by rectification. 150 p
How rectified from metals or verdigrease. 150, 151 p
Rectified from verdigrease, its virtue. 152 p
Its rob, or extract. 147, 148, 149 p
Affords a strong, fixed alkali. 148, 149, 150 p
Virtues thereof. 149 p
Affords an inflammable liquor distill'd from lead. 148
A more elaborate production than wine. 148 p
Impaired by boiling with animal substances. 150 p
Its proportion of acid salt. 185 p
Differs from other acids. 186 p
Thins the blood. 231, 232 p
Vinum Emeticum, how made and used. 310 p
See *Wine*.
Vitriol, what and whence denominated. 134, 135, 136, 264 p
Native, of two kinds. 135 & n. 136
Whether any be strictly native. 135 & n
Whence obtain'd. 135 & n. 264 p
Always found with copper. 90
How form'd in the earth. 112 & n. 113 & n. 254 p
Difficult of fusion. 84
Its diversity of colour, whence. 135 n
Roman, how procured. 135 n
Green, how made. 135 n
Made from copper both with acids and alkalies. 135 n
White. 135 & n. 136
Said to afford gold. 136
Its component parts. 136
Its analysis and recomposition. 136 & n. 299 p
Its acid, what. 136, 254 p. 301 p
Artificial, made from all kind of metals 135 & n
Participates of the menstruum as well as the metal. 135 n. 136
Call'd metallic salt. 136
Vitriols of metals, how gained. 353, 354, 264 p
Of iron, its virtues and uses. 264 p
Its spirit, oil, and colcothar, how procur'd. 299 p
Affords not all its acid by distillation. 299, 300 p
Ulcers foul, how cleansed. 48 p
How cleansed and cured. 163, 170, 171 p
Ultramarine, what and how made. 137 & n
By what exceeded. 286, 287
Unguentum Nutritum, what and how made. 273 p
Universal Medicine, when first pretended to. 12, 13
Unknown to the antients. 12, 13
The notion probably derived from *Geber*. 13, 15
Whether known to *Paracelsus*. 27, 28
Van Helmont. 33, 36
Probably not to any one. 36
Volatility, the notion thereof in chemistry. 63
Whence it proceeds. 228 n. 291 n. 339
See *Fixedness*.
Volatilization effected universally by the air. 280
Vomit, a sudden one in case of poison. 151 p
186 p
Vomiting, remedies against it. 64 p. 83 p
Urine, its nature and contents. 187 p
Natural properties thereof. 187 p
Morbid, differs from the healthy. 187, 188 p
Affords nothing acid nor alkaline by distillation. 188, 189, 190 p
Its analysis. 188 p
Contains no inflammable spirit. 188, 189 p
the sharpest salts of the body. 189 p
How to be regarded and judged of as a sign. 189 p. 194, 195 p
Its rob distilled with sand. 189, 190 p
Contains sea-salt. 188, 189, 190 p. 197 p
Turn'd alkaline by being distilled with fixed alkali. 190, 191 p
Distilled with quick-lime, what it yields. 191, 192 p
Its fiery spirit when distilled from quick-lime. 191 p
Its medicinal uses. 192 p
Crystallized. 193 p
Its essential salt how obtained. 193 p
the nature thereof. 193 p
How digested. 194 p
Turned alkaline by digestion. 194 p
F
Urine

I N D E X

Urine, its suppression, where mortal. 195 p
 Digested, its analysis. 145, 146 p
 As a sign to be judged of from chemistry. 196, 197
 Its use in scouring, and dying. 321, 194 p
 Shewn to be naturally neither acid nor alkaline. 186, 187 p
 In what time perfected in the body. 187 p
 Apt to putrefy, or turn alkaline in the body. 189, 190 p
Uterine Medicines. 83, 84 p. 163 p
Vulcan, or *Tubal Cain*, the inventor of chemistry. 5, 6, 8
Vulcanos, whence. 261, 254 p. 328 p
 See *Earthquakes*.

W.

W *Arts*, how taken away. 48 p
Water, its nature, specific gravity, &c. 59, 305, 310, 318, 319
 How varied. 310
 The vehicle of earth. 120
 Whether a principle. 140, 141, 176 n
 Whether an insipid salt. *ib.*
 How necessary to plants. 95, 96 p
 Whether the nutriment thereof. 144, & n.
 Is a proper vehicle of nutritious particles. 308, 315
 Contain'd largely in animal bodies. 168, 169
 Distill'd, whether it will serve for vegetation. 185 n. 308
 From animals, what, and how distinguish'd. 220, 221 p
 Its effects in chemical operations. 219
 Can scarce be excluded from bodies. *ib.*
 Boiling, the standard of heat. 272, 324
 Its utmost effect on vegetables. 22, 23 p
 Resembles crystal. 305, 309
 Never obtainable pure. 305, 306, 310
 To examine its purity. 312 n. 313
 A mixture of numberless things. 141, 305, 306, 310
 An universal agent or instrument. 306
 Conceived as such by *Paracelsus* and *Helmont*. 366
 Contain'd in all bodies. 306, 316, 95, 96 p. 217 p
 Large quantities thereof in divers solid and fluid bodies. 306, 308, 309 n. 316, 95, 96 p. 217 p
 Present in all places. 306
 Enters the composition of all bodies. 315, 95, 96 p
 Calls out the active parts of bodies. *ib.*
 Whence held the seminal principle of all things. 306, & n. 307, & n. 319, & n.
 Of the *Mosaic* creation, what. 306 n. 307 n.
Fresh, whence. 307 n.

Whether all bodies be convertible into it. 308, & n
 Whether it be convertible into earth. 308, 312, 313, & n. 325, 326, & n. 362, 30 p
 Whether into air. 313, n. 314
 Naturally firm, or solid. 309, 310, & n
 How turned to ice. *ib.* & n
 Ice, how kept fluid by fire. 222, & n. 305
 In constant motion. 309, 310, & n
 Which the purest. 310, 312
 Rain, salt after thunder. 310
 That of springs, whence. *ib.* & n
 Why best in running streams. 311
 Of rivers less pure than that of springs. *ib.*
 Of some rivers fermentable, whence. 119, 120 p
 Growing sweet again after putrefaction. 311 n
 Rough, or hard, how remedied. *ib.*
 The lightest, best and wholesomest. 311, 312, & n
 Salt water, various ways to make it sweet and potable. *ib.*
 To discover the quantity of salt therein. *ib.*
 Whether it may long be kept pure. 313
 What happens to pure water in keeping. *ib.*
 Its various effects in chemical operations. 314
 Which best for watering of land. *ib.*
 Is exceedingly penetrative. *ib.*
 Retainable, in what vessels. 315
 Will pass thro' gold. 315, 317
 Whether more fluid than air. 315, & n
 Easily separable from bodies, it is united to. 315
 Renders many bodies solid and hard. 315, 316, 95 p
 Its tenacity. 95
 Is the universal gluten. 317, 217, 218 p
 Not compressible, nor elastic. *ib.*
 How it bursts bodies wherein it is confined. *ib.*
 Why it expands by heat, and contracts by cold. *ib.* & n. 318 n
 Expands in freezing. 318 n
 Its force in contracting ropes. 318 n
 Too hot, coagulates the animal juices. 207 p
 Approaches the nature of mercury. 319
 Esteem'd the matter of metals. 371
 Tasteless, scentless, and only distinguishable by touch. 319
 By standing yields a tincture and spirit. *ib.*
 Considered as a menstruum, to saline, metalline, saponaceous, &c. bodies. 320, 321
 When the best menstruum. 159 p
 Dissolves some salts after saturated with another kind. 320
 Repels unctuous bodies. 320, 221
 Dissolves not sulphurous bodies nor earth. 321
Water,

I N D E X.

- Water*, how made to dissolve oily bodies. 320.
321
With salts makes crystals. *ib.*
The grand instrument of fermentation and
putrefaction. 321, 322. 120. p. 175, 176. p
Of effervescence. 322
Separates oils from salts. 322, 323
From alcohol. 323
Acid spirits from their solvents. 323
Its uses, in distillation, precipitation, volatil-
ization, and regulation of fire. 323, 324
Its share in the action of all menstruums. 242
Odoriferous and medicinal, how and from
what vegetables best procured. 15. p
How preserved. 16. p
Not pure. *ib.*
How distill'd vulgarly. 57, 58. p
How ——— from fermented vegetables
per vesicam. 65 — 68. p
Their virtues excellence and uses. 67. p
How improv'd by cohobation. 61. p. 63, 64. p
Whence their taste and scent. 67. p. 82. p
How obtainable to best advantages. 17, 18. p
Their uses. 19, 20. p
Not safely imitated with essential oil. 20. p
Vomitive, whence. 58. p
Of succory, will kill worms, &c. 60. p
Chalibent, when fit for use. 265. p
Water-poise, that of Dr. Hook. 312. n
Wax, what. 153. 106. p
How procured. 153. 8n
How analysed. 105, 106. p
A kind of camphire. 106. p
Peculiarities of its oil and butter. 105, 106. p
Weather, its changes whence and how best fore-
told. 151. n. 152. n. 245, 246. 285
Weight of bodies corresponds to their reality.
99
Winds lessen the pressure of the atmosphere. 287
Wind-furnace, what. 380
Its use. *ib.*
How best made. 380, 381
Wines, what, and whence procurable. 213,
214. 117. p. 123. p. 135. p
Their physical properties. 130, 131. p
The process in making them. 129. p
How made from corn, pulse, and nuts. 126. p
127. p
How made strong by standing on the lees.
130. p. 133. p
Pure, alterable by the fumes of new wine.
288
- Canary*, retain their taste when other things
lose theirs. 299
Retain not the taste of the subjects whence
they were made. 131. p
What they contain. *ib.*
When most disposed to fret in the cask.
132. p
How to be treated for distillation. 133. p
Which best for that use. 147. p
Afford different liquors at different times
of the distillation. 134, 135. p
How made into vinegar. 142, 143. p. 144
Which least apt to inebriate. 147. p
How preserved by their tartars. 153. p
Portable, what and how made. 28. p
Toothless, what. 155. p. 8n
Wood, why some is said to yield no smoke. 327
Whence its durability, corruption, &c. 90,
91. p
Subject to two kinds of rottenness. 91. p
How affected by the worm. *ib.*
by time. *ib.*
Which best to distil for oil. 89, 90. p
The least oily the lightest. 90. p
Wool, how scoured. 321
Wounds, how healed to advantage. 104. p
Without suppuration, or cicatrix. 118. p
Worms, Remedies against 'em. 84. p. 109, p
218. p. 264. p. 270. p. 286. p. 287. p. 290. p
296. p. 311. p
Worm of a Still, what. 380, 56. p
Wormwood-water, its virtue. 64, 65. p
- Y.
- Y**east, what. 121. p
Yolk, see eggs.
- Z.
- Z**ink, what. 134. 8n. 347
Gives a gold colour to copper. 88. n
134
Purifies tin. 134
How dissolved by vinegar. 346, 347
Zozimus Panopolitanus, his history and writ-
tings. 2, 3. 8n. 14
Zuchten (*Alex. Van*) character of his writings.
44
His way of preparing the Philosopher's
stone. 44, 45
Zythum, what. 214. n. 126. p

T H E E N D.

X. H. O. M. I.

